

**EIS
SUB-APPENDIX D
NATURAL RESOURCE REPORTS**

**FINAL
FEASIBILITY REPORT
AND ENVIRONMENTAL IMPACT STATEMENT
PORT EVERGLADES HARBOR NAVIGATION STUDY
BROWARD COUNTY, FLORIDA**

Appendix D

D-1

Baseline Report

Environmental Baseline Study and Impact Assessment for Port Everglades Harbor

Final Report



May 31, 2001

**Prepared for:
Jacksonville District
U.S. Army Corps of Engineers
400 West Bay Street
Jacksonville, FL 32202**

**Prepared by:
Dial Cordy and Associates Inc.
490 Osceola Ave.
Jacksonville Beach, FL 32250**

TABLE OF CONTENTS

	Page
LIST OF APPENDICES	V
LIST OF FIGURES.....	VI
LIST OF TABLES	VII
1.0 INTRODUCTION	1
1.1 Background.....	1
1.2 Proposed Study Element Descriptions.....	3
2.0 TECHNICAL APPROACH	6
2.1 Terrestrial Resources	6
2.1.1 Existing Data Collection and Review	6
2.1.2 Field Verification and Mapping.....	6
2.2 Marine Resource Survey.....	6
2.2.1 Seagrass Community	6
2.2.1.1 Location of Survey Transects.....	7
2.2.1.2 Seagrass Mapping	7
2.2.1.3 Seagrass Occurrence, Abundance, and Density.....	7
2.2.1.4 Analysis and Interpretation of Seagrass Data	10
2.2.2 Hardbottom and Reef Habitat Assessment	10
2.2.2.1 Habitat Characterization and Mapping	10
2.2.2.2 Visual Fish Survey.....	11
2.2.2.3 Photodocumentation	11
2.2.3 Essential Fish Habitat Identification.....	11
3.0 ENVIRONMENTAL BASELINE.....	13
3.1 Terrestrial Resources	13
3.1.1 Land Use and Biotic Community Cover Types	13
3.1.2 Jurisdictional Wetlands.....	18
3.1.3 Local Areas of Particular Concern.....	18
3.2 Marine Resources.....	20
3.2.1 Seagrass Communities.....	20
3.2.1.1 Seagrass Species Frequency of Occurrence, Abundance, and Density.....	20

3.2.1.2 Associated Marine Plants and Animals	25
3.2.2 Hardbottom and Reef Communities	25
3.2.2.1 Hardbottom and Reef Distribution	26
3.2.3 Unvegetated Bottom Communities.....	31
3.2.4 Essential Fish Habitat	32
3.3 Threatened and Endangered Species.....	32
3.3.1 Terrestrial Species.....	32
3.3.2 Marine Species.....	34
3.3.2.1 H. johnsonii.....	34
3.3.2.2 Manatee.....	34
3.3.2.3 Sea Turtles	34
4.0 IMPACT ASSESSMENT.....	40
4.1 Alternatives S-1A, S1-B	40
4.1.1 Impacts to Terrestrial Resources.....	40
4.1.2 Impacts to Marine Resources.....	49
4.1.2.1 Impacts to Seagrass	49
4.1.2.2 Impacts to Hardbottom and Reef	50
4.1.2.3 Impacts to Unvegetated Habitats	51
4.1.2.4 Impacts to EFH	52
4.2 Alternatives S-5A, S-5B	53
4.2.1 Impacts to Terrestrial Resources.....	53
4.2.2 Impacts to Marine Resources.....	53
4.2.2.1 Impacts to Seagrass	54
4.2.2.2 Impacts to Unvegetated Habitats	54
4.2.2.3 Impacts to EFH	55
4.3 Alternatives S-6A, S-6B	55
4.3.2 Impacts to Terrestrial Resources.....	56
4.3.3 Impacts to Marine Resources.....	56
4.3.3.1 Impacts to Seagrass	56
4.3.3.2 Impacts to Unvegetated Habitats	56
4.3.3.3 Impacts to EFH	57
4.4 Alternatives S-7, S-8.....	57
4.4.1 Impacts to Marine Resources.....	57
4.4.1.1 Impacts to Seagrass	58
4.4.1.2 Impacts to Unvegetated Habitats	58
4.4.1.3 Impacts to EFH	58

4.5	Alternatives S-9	59
4.5.1	Impacts to Terrestrial Resources.....	59
4.5.2	Impacts to Marine Resources.....	59
4.5.2.1	Impacts to Unvegetated Habitats	60
4.5.2.2	Impacts to EFH	60
4.6	Impacts to Threatened and Endangered Species	60
4.6.1	Impacts to Threatened and Endangered Species - All Alternatives	60
5.0	DREDGED MATERIAL DISPOSAL OPTIONS	64
5.1	Offshore Dredged Material Disposal Site (ODMDS).....	64
5.2	Beach Placement	64
5.3	Airport Stockpile.....	64
5.4	Beneficial Uses for Habitat Creation and Restoration	66
6.0	COMPENSATORY MITIGATION OPTIONS	67
6.1	Mitigation Policies	67
6.2	Mitigation Options	70
6.2.1	West Lake	70
6.2.2	Dania Cutoff Canal Property.....	72
6.2.3	Florida Power & Light Everglades Mitigation Bank	72
6.2.4	John U. Lloyd SRA Mangrove and Shallow Water Habitat Replanting.....	73
6.2.5	Offshore Artificial Reef Placement	73
6.3	Effectiveness of Available Mitigation Options.....	73
6.3.1	Mangrove Restoration and Creation	73
6.3.2	Seagrass Restoration	74
6.3.3	Artificial Reef Construction.....	75
6.3.4	Land Acquisition and Preservation	76
7.0	REFERENCES	77

LIST OF APPENDICES

Appendix A	Sources of Information
Appendix B	Florida Natural Area Inventory Listed Species, Broward County
Appendix C	Survey Photographs
Appendix D	Seagrass Field Data Sheets (2000 Survey)
Appendix E	Bird Species List, Broward County

LIST OF FIGURES

	Page
Figure 1 Location of Study Area.....	2
Figure 2 Study Elements - 1.....	4
Figure 3 Study Elements - 2.....	5
Figure 4 Survey Transect Locations	8
Figure 5 1995 Florida Land Use/Cover Classification (FLUCCS).....	14
Figure 6 Estimated Wetland Areas	17
Figure 7 Local Areas of Particular Concern	19
Figure 8 Seagrass Distribution - Northern Portion of Study Area	21
Figure 9 Seagrass Distribution - Southern Portion of Study Area.....	22
Figure 10 Nearshore Marine Resource Cover Map	27
Figure 11 Hardbottom and Reef Habitat Distribution	28
Figure 12 Overview of Threatened and Endangered Species	35
Figure 13 Seasonal Pattern of Daily Loggerhead Nesting in Broward County, 1999	38
Figure 14 Historical Patterns of Yearly Hatchling Success for All Evaluated In-Situ and Relocated Sea Turtle Nests Since 1981	39
Figure 15 S-1A Project Footprint and Associated Impacts.....	42
Figure 16 S-1B Project Footprint and Associated Impacts.....	43
Figure 17 S-5A Project Footprint and Associated Impacts.....	44
Figure 18 S-5B Project Footprint and Associated Impacts.....	45
Figure 19 S-6A Project Footprint and Associated Impacts.....	46
Figure 20 S-6B Project Footprint and Associated Impacts.....	47
Figure 21 S-7, S-8, and S-9 Project Footprints and Associated Impacts	48
Figure 22 Mitigation/Disposal Option Locations	65
Figure 23 West Lake Park Location Map	71

LIST OF TABLES

	Page
Table 1 Habitat Classification System Used for Mapping of Seagrass Species	9
Table 2 Classification System Used for Mapping of Hardbottom and Reef Habitats	12
Table 3 Florida Land Use Cover Classification System Categories Within the Project Boundaries	15
Table 4 Seagrass Frequency of Occurrence, Abundance, and Density Values for Port Everglades Survey Transects for 1999-2000 Survey	24
Table 5 Relative Abundance of Fish Species Observed During Visual Survey Port Everglades, Florida	30
Table 6 Essential Fish Habitat Areas in South Florida	33
Table 7 Summary of Sea Turtle Nesting for John U. Lloyd SRA, 1994-1999	37
Table 8 Impact Acreages by Habitat Type	41
Table 9 Impact Analysis of Study Elements	61

1.0 INTRODUCTION

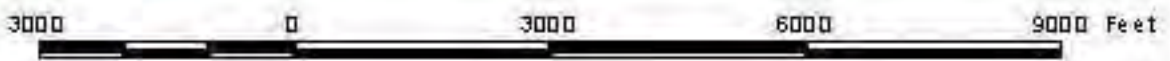
Dial Cordy and Associates Inc. (DC&A) was subcontracted by Gulf Engineers and Consultants, Inc. (GEC) to conduct an environmental baseline and impact assessment for proposed deepening and widening of Port Everglades, Broward County, FL for the U.S. Army Corps of Engineers, Jacksonville District, under contract No. DACW17-99-D-0043.


The environmental baseline survey and impact assessment included, the collection and review of literature and existing data, field investigations to characterize marine and terrestrial habitats within the areas to be potentially impacted, a compilation of this information and an assessment of impacts associated with deepening and widening activities to the resources identified. Data was collected in an initial seagrass survey in 1999 (DC&A 1999), terrestrial surveys and additional seagrass mapping in 2000, and an outer entrance channel integrated video mapping survey in May 2001. The data collected during this study and related composite resource maps are summarized in this report.

1.1 Background

Port Everglades Harbor Federal Navigation Channel is located in the southeastern section of Broward County, FL (Figure 1). Port Everglades was initially constructed in 1925-28. The development was funded by the cities of Hollywood and Fort Lauderdale and a private developer. The initial project consisted of an entrance channel, a turning basin, a slip, two bulkheads, two rock jetties, and two submerged breakwaters. The River and Harbor (R&H) Act of 1930 authorized Federal maintenance of the locally constructed entrance channel, turning basing and rock jetties. The non-Federal sponsor constructed the most recent modifications to Port waterways between 1984 through 1991. These modifications were phased using five separate construction contracts. The result of these improvements included deepening of the Southport Access Channel (SAC) from the Main Turning Basin (MTB) to the Dania Cutoff Canal (DCC) to a project depth of 42 feet, and construction of the Turning Notch (TN) to a depth of 42 feet. The present Port Everglades Federal Navigation Project provides for an Outer Entrance Channel (OEC) that is 45 feet deep and 500 feet wide, an Inner Entrance Channel (IEC) that is 450 feet wide and 42 foot deep, a Main Turning Basin (MTB) that is 42 feet deep, a North Turning Basin (NTB) that is 31 feet deep, a South Turning Basin that is (STB) 31 to 36 feet deep, a Southport Access Channel (SAC) that is 400 feet wide and 42 feet deep, and a Turning Notch (TN) that is 42 feet deep. This study also addressed the widening of the SAC across Berths 25 and 26. The Feasibility Study presently underway was authorized by a resolution of the House Committee on Transportation on May 9, 1996. The resolution reads, in part, as follows:

"Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, that, the Secretary of the Army is requested to review the reports of the Chief of Engineers on Port Everglades Harbor, Florida, published as House Document 126, 103rd Congress, 1st Session, and House Document 144, 93rd



Location of Study Area	
Port Everglades Baseline Environmental Resource Survey	
Scale: 1" = 3,000'	Drawn By: M.R.
Date: May, 2001	Approved By:
 DIAL, CORDY AND ASSOCIATES, INC. Environmental Consultants	JDD-426 Figure 1

Congress, 1st Session, and other pertinent reports to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of navigation and related purposes, with particular reference to navigation into and within the part of the project known as the Southport Channel."

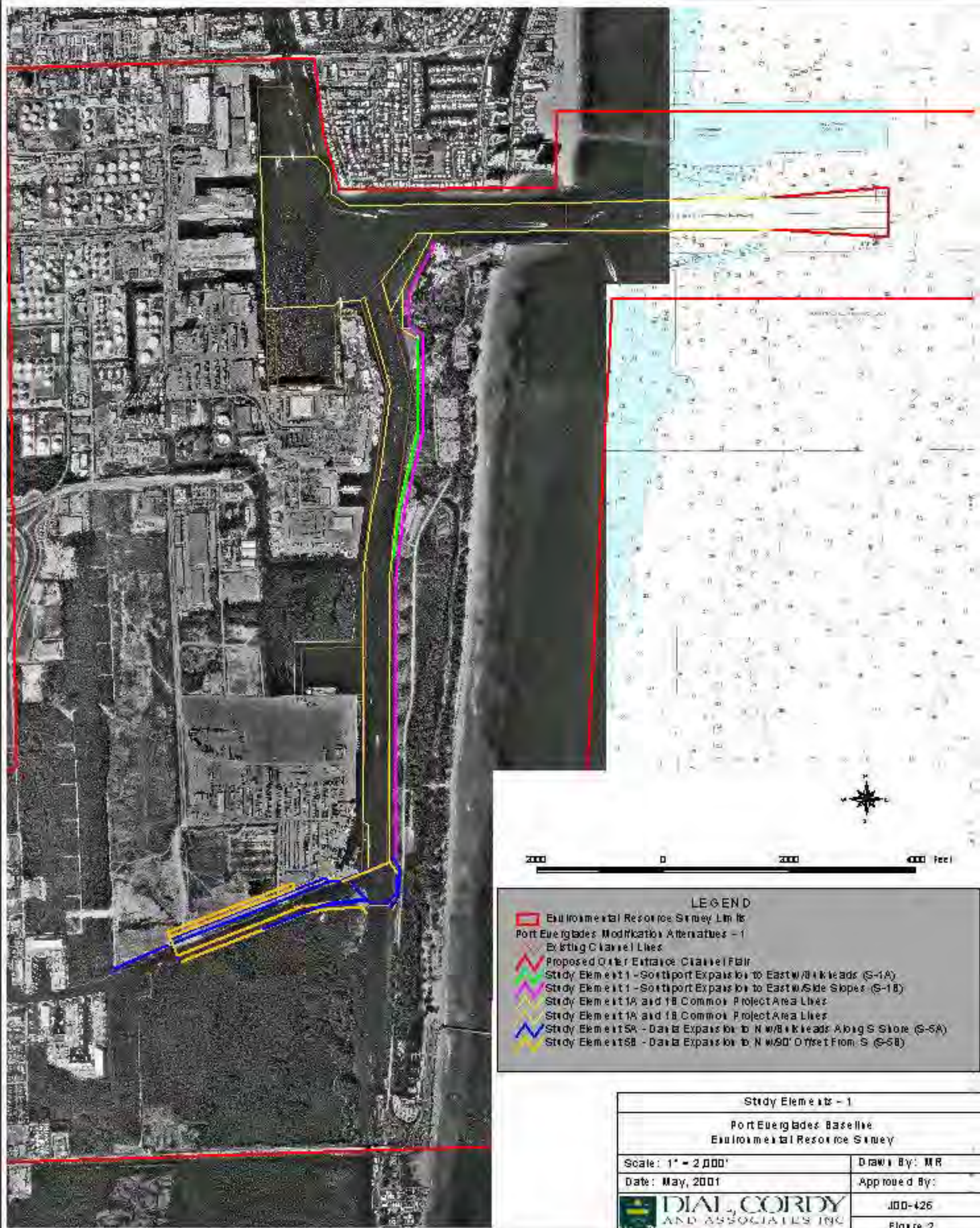
On June 29, 1999 the project was re-scoped based on future development plans. The re-scope included a modified study to address the future need to bring larger Post Panamax size vessels, and cruise ships such as the Royal Caribbean Eagle Class vessels into the Port.

1.2 Proposed Study Element Descriptions

Proposed study elements can be seen in Figures 2 and 3. A description of the proposed alternatives is as follows:


No Action Plan	Port would continue operation under the existing conditions.
Alternative S-1A	Southport expansion to the east, to include deepening of AICW to a maximum of 58 feet and widening of the channel, with a bulkhead along eastern side of area. Also includes deepening Outer Entrance Channel (OIC), Inner Entrance Channel (IEC), Main Turning Basin (MTB) and removal of widener shoal.
Alternative S-1B	Southport expansion to the east, to include deepening of AICW to a maximum of 55 feet and widening of the channel, with a side slope along eastern side of area. Also includes deepening Outer Entrance Channel (OIC), Inner Entrance Channel (IEC), Main Turning Basin (MTB) and removal of widener shoal.
Alternative S-5A	Widening of the Dania Cutoff Canal to the north with an 80' offset to the south. Deepening of canal to a depth of 36'. On north side, construction of bulkhead, on the south side a bulkhead constructed in West Lake Park.
Alternative S-5B	Widening of the Dania Cutoff Canal to the north with an 80' offset to the south. Deepening of canal to a depth of 36'. On north side, construction of bulkhead, on the south side a sideslope constructed just north of West Lake Park.
Alternative S-6A	Widening of the Dania Cutoff Canal to the south. Deepening of canal to a depth of 36'. On north side, construction of bulkhead, on the south side a bulkhead constructed in West Lake Park.
Alternative S-6B	Widening of the Dania Cutoff Canal to the south. Deepening of canal to a depth of 36'. On north side, construction of bulkhead, on the south side a sideslope constructed just north of West Lake Park.
Alternative S-7	Deepen North Turning Basin to 55'.
Alternative S-8	Deepen South Turning Basin to 55'.
Alternative S-9	Expansion of the Turning Notch to the West and North.

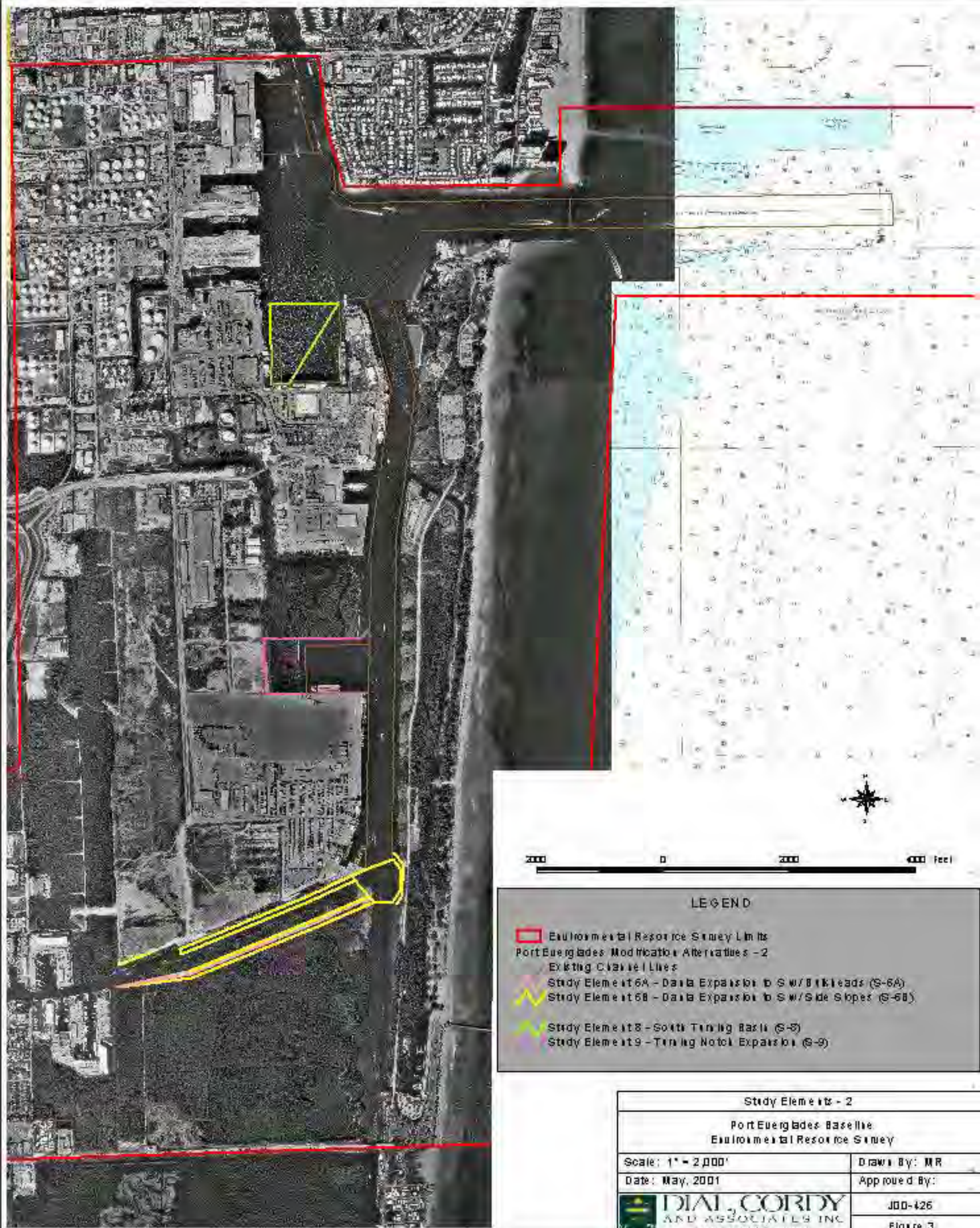
The described study elements include consideration of four different disposal options for dredged material. Alternative descriptions with related disposal options will be discussed further in the impacts section.



LEGEND

- Environmental Resource Study Limits
- Port Everglades Modification Alternatives - 1
- Existing Channel Lines
- Proposed Outer Entrance Channel Fair
- Study Element 1 - Southport Expansion to East W/Bike Leads (S-1A)
- Study Element 1 - Southport Expansion to East W/Side Slopes (S-1B)
- Study Element 1A and 1B Common Project Area Lines
- Study Element 1A and 1B Common Project Area Lines
- Study Element 5A - Docks Expansion to NW/Bike Leads Along S Shore (S-5A)
- Study Element 5B - Docks Expansion to NW/50' Offset From S (S-5B)

Study Elements - 1	
Port Everglades Baseline Environmental Resource Study	
Scale: 1" = 2,000'	Drawn By: MR
Date: May, 2001	Approved By:
 DIAL CORDY AND ASSOCIATES INC. ENVIRONMENTAL CONSULTING	JDD-426
	Figure 2



2.0 TECHNICAL APPROACH

This section describes the technical approach used to collect and analyze data associated with the environmental baseline study. Resource surveys were conducted in late summer 1999, 2000 and in May 2001.

2.1 Terrestrial Resources

2.1.1 Existing Data Collection and Review

Prior to the commencement of field investigations, existing data regarding present and historic conditions of natural resources were assembled and reviewed. Once reviewed, the data were compiled into GIS resource files identifying probable current conditions, significant resources, and questionable areas. A list of sources contacted to obtain relevant data and corresponding natural resources information is located in Appendix A.

2.1.2 Field Verification and Mapping

Field surveys were conducted on 26-27 September 2000 to verify the preliminary resource maps and to identify any additional environmental constraints. Areas of potential jurisdictional wetlands were given particular attention with regard to hydrological, soil, and vegetative characteristics according to the *1987 Corps of Engineers Wetlands Delineation Manual* and the *Florida Wetlands Delineation Manual* (1995). Presence or absence of any indicators of state or federally protected flora and fauna or their habitat was also determined. A list of potential protected species for all of Broward County is included in Appendix B.

2.2 Marine Resource Survey

A description of methods utilized to document and characterize marine seagrass, hardbottom, and coral reef communities within the study area (Figure 1) are described below. Surveys were conducted on September 6-10, 1999 (DC&A 1999), September 19-21, 2000, and May 16-17, 2001.

2.2.1 Seagrass Community

Descriptions of methods used to assess seagrass communities within the Port area are included in this section.

2.2.1.1 Location of Survey Transects

The location of survey transects for the 1999 survey ranged from approximately 1200 feet north of Port Everglades Inlet south to about 1000 feet south of the DCC and along the DCC to Port Denison (Figure 4). For the 2000 survey, transects were located within the area 1000 feet south of the DCC on the east side of the channel, and on the west, from the DCC south to the Dania Beach Boulevard Bridge (Figure 4).

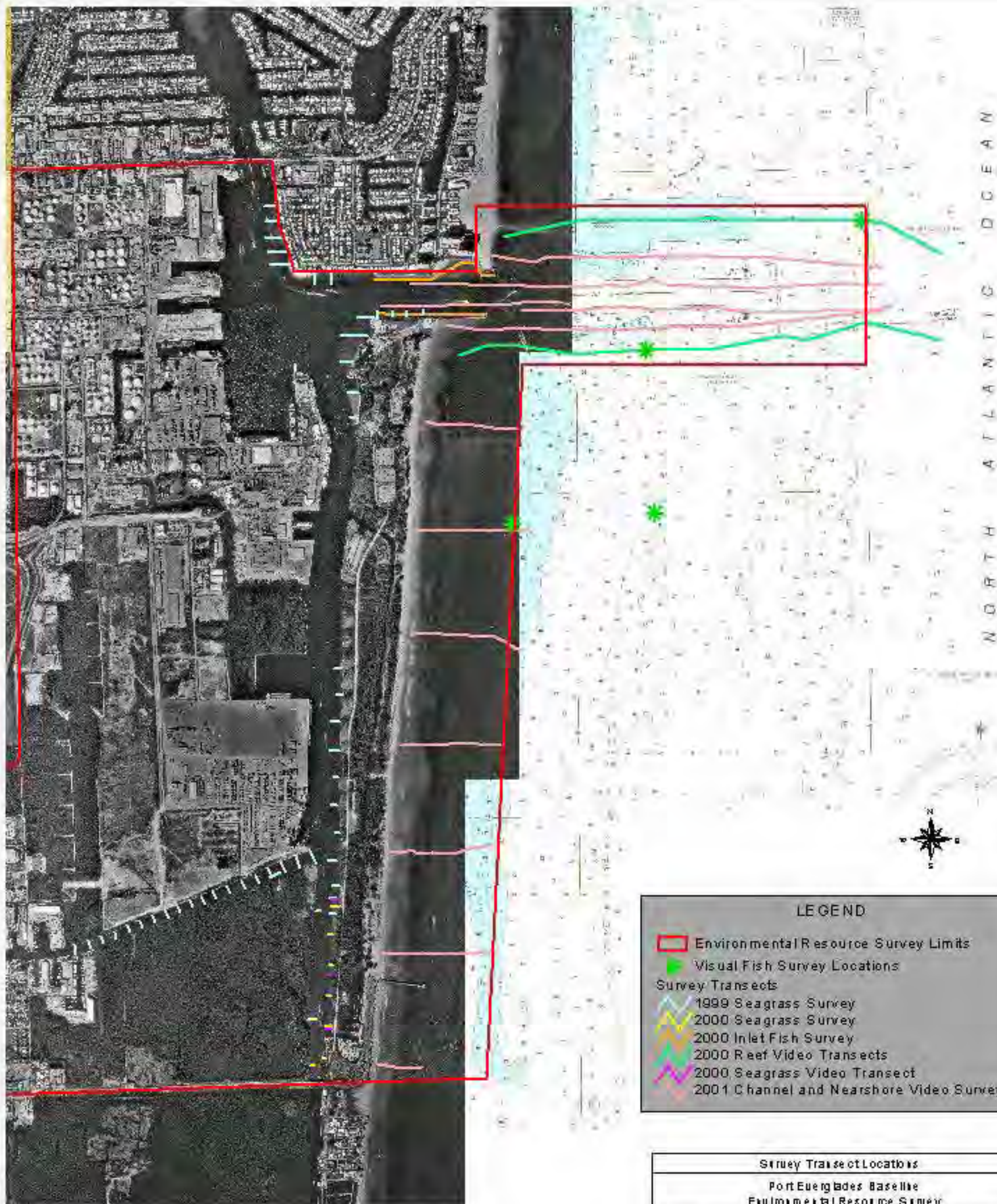
2.2.1.2 Seagrass Mapping

Marine seagrass distribution was mapped along each of the 62 transects by locating the end positions using Differential Global Positioning System (DGPS), laying a weighted line marked in one meter increments from the shore, and then conducting a visual diver survey along the weighted line to document seagrass distribution and occurrence from the shore to the edge of channel. Seagrass habitat and bottom type observed while crossing each transect were noted. Divers drift dove to the next transect, and if any seagrass was found between transects, a GPS position at the start and end of the grass bed was recorded, and the width of the grass bed estimated. Information recorded on seagrass habitat type and distribution was transferred from field logs and entered into a spreadsheet. Descriptions of habitat classifications are shown in Table 1. This approach allowed a visual representation of species' associations and occurrences across the shelf, channel, and slope as compared with bottom depth. Maps were produced for all stations surveyed that had seagrass present. A GIS map (ArcView) and database were created to illustrate seagrass distributions throughout the study area.

2.2.1.3 Seagrass Occurrence, Abundance, and Density

To obtain biological data regarding the location, occurrence, abundance, and density of marine seagrass, a SCUBA point intercept survey was performed along each transect. For each transect, the average percent (percent of sixteen 25 x 25 cm sub-units within a 1m² quadrat that contains at least one seagrass shoot) was estimated in 1m² quadrats at 10m intervals along the transect line (Virnstein 1995; Fonseca et al. 1998; Braun-Blanquet 1965). Specific data recorded within each 1m² quadrat for each seagrass species present included the number of sub-units containing at least one shoot, an average cover abundance score (Braun-Blanquet 1965), a description of substrate type, and any other observations considered useful. The cover abundance scale is discussed below.

The cover abundance scale was computed beginning at the zero point and at 10m intervals along each transect. The content of each quadrat was visually inspected and a cover abundance scale value assigned to the seagrass coverage.



LEGEND

- Environmental Resource Survey Limits
- ★ Visual Fish Survey Locations
- Survey Transects
 - 1999 Seagrass Survey
 - 2000 Seagrass Survey
 - 2000 Inlet Fish Survey
 - 2000 Reef Video Transects
 - 2000 Seagrass Video Transect
 - 2001 Channel and Nearshore Video Survey

Survey Transect Locations

Port Everglades Baseline
Environmental Resource Survey

Scale: 1" = 2,500'

Drawn By: MR

Date: May, 2001

Approved By:



JDD-426

Figure 4

Table 1 Habitat Classification System Used for Mapping of Seagrass Species

Habitat Types	Description
<i>Halophila decipiens</i>	Monospecific bed of this species
<i>Halophila johnsonii</i>	Monospecific bed of this species
<i>Halodule wrightii</i>	Monospecific bed of this species
<i>Syringodium filiforme</i>	Monospecific bed of this species
Mixed Submerged Aquatic Vegetation	<i>S. filiforme</i> or <i>H. wrightii</i> with <i>H. decipiens</i>
Mixed Submerged Aquatic Vegetation with <i>H. johnsonii</i>	<i>S. filiforme</i> and or <i>H. wrightii</i> with <i>H. johnsonii</i>
Mixed Submerged Aquatic Vegetation with <i>H. johnsonii</i> and <i>H. decipiens</i>	<i>H. wrightii</i> with both species of <i>Halophila</i>
Unvegetated Bottom	Sand, silt or shell substrate with no seagrass or live bottom, may have marine algae present
Live-Bottom Habitat	Sponge and soft coral community over thin veneer of silty-sand

The scale values are:

- 0.1 = Solitary shoots with small cover
- 0.5 = Few shoots with small cover
- 1.0 = Numerous shoots but less than 5% cover
- 2.0 = Any number of shoots but with 5-25% cover
- 3.0 = Any number of shoots but with 25-50% cover
- 4.0 = Any number of shoots but with 50-75% cover
- 5.0 = Any number of shoots but with >75% cover

From the survey of quadrats along each transect, frequency of occurrence, abundance, and density of seagrass was computed as follows:

Frequency of occurrence = Number of occupied sub-units/total number of sub-units

Abundance = Sum of cover scale values/number of occupied quadrats

Density = Sum of cover scale values/total number of quadrats

2.2.1.4 Analysis and Interpretation of Seagrass Data

Distribution of seagrass community types and their potential occurrence in an area were mapped for each transect from survey data. Frequency of occurrence, abundance, and density were calculated from the quadrat data based on Braun-Blanquet (1965) methodology.

2.2.2 Hardbottom and Reef Habitat Assessment

In the area offshore (from the jetty in the federal channel to 2,000 feet offshore and 500 feet north and south of the outer channel), a reef and hardbottom assessment was conducted to verify existing resource maps and to generally characterize the marine resources in the study area. To verify the accuracy of existing reef and hardbottom maps (USACE 1992), towed underwater video in conjunction with DGPS was used to record and mark the occurrence of hardbottom or reef habitats along six transects located within the survey area (500 feet north and south of federal channel) (Figure 4). Video and field data collected were used to assess the accuracy of existing maps of reef and nearshore hardbottom habitat types within the study area.

2.2.2.1 Habitat Characterization and Mapping

To illustrate the occurrence of reef and hardbottom habitat types within the study area existing resource maps of the area were compared to video data. To document the nearshore hardbottom communities off John U. Lloyd SRA, digitized aerial photographs were analyzed

using a multi-spectral image analysis classification (ERDASTM). Brief ground truthing of the image analysis was performed on May 16 - 17, 2001 by using an integrated towed video system. Eight transects were surveyed from the shore to 2000 feet seaward. The classification system utilized for mapping is described in Table 2. Following compilation of habitat distribution in reef and hardbottom communities, data were transferred into a database for mapping purposes using ArcView (GIS). A visual representation of habitat types was constructed using these data and existing maps for the Port Everglades area.

2.2.2.2 Visual Fish Survey

A visual survey of fishes found within the Port Everglades federal channel, reef, and nearshore hardbottom communities was performed. Reef and hardbottom communities were chosen from stations where DGPS coordinates were taken in conjunction with towed video documentation of reef or hardbottom sightings. At reef and hardbottom areas, divers were deployed along a 50m transect and all dominant fish species observed were recorded, and relative abundance was gauged. Along both sides of the federal channel, divers conducted visual surveys from the turning basin to the end of the jetty. During the visual surveys, dominant species and relative abundances were recorded. Species lists were then compiled using existing reports and data collected.

2.2.2.3 Photodocumentation

Along each visual fish survey transect, both video and still photo documentation were used to characterize invertebrate and fish species that were present along each transect. Video was recorded along each side of the 50m transect while still photographs (Appendix C) were taken randomly along the length of each transect.

2.2.3 Essential Fish Habitat Identification

The comprehensive Fishery Management Plan prepared by the South Atlantic Fishery Management Council (SAFMC 1998) establishes mangrove, seagrass, and nearshore and offshore reefs as Essential Fish Habitat (EFH) for coral, coral reefs, live-bottom habitat, Snapper-Grouper Complex, red drum, penaeid shrimp, and coastal migratory pelagics. Furthermore, the plan establishes Essential Fish Habitat-Habitat Areas of Particular Concern (EFH-HAPC) within these areas for the spiny lobster (*Panulirus argus*), Snapper-Grouper Complex, and penaeid shrimp. Areas meeting the criteria of the management plan were identified within the study area and noted during the study.

Table 2 Classification System Used for Mapping of Hardbottom and Reef Habitats

Habitat Type	Description
Low -Relief Reef	Low profile stony coral, sponge, and gorgonian community
High-Relief Reef	High profile stony coral, sponge and gorgonian community
Scattered Rock and Rubble	Carbonate rock covered with algae, sponge or algae and sponge in sand
Sand	Softbottom habitats composed primarily of sand/sand with algae layer
Variable Hardbottom with Sand	Oolitic limestone layer covered with fine layer of sand
Scattered Hardbottom with Sand	Variable rock layers interspersed with areas of softbottom
Predominately Sand w/ isolated rock	Softbottom habitat with small areas of exposed rock

3.0 ENVIRONMENTAL BASELINE

This section describes the general habitat types found within the Port Everglades area. The results of the 1999 (Dial Cordy 1999), 2000, and 2001 surveys are summarized, with terrestrial and marine resources covered.

3.1 Terrestrial Resources

3.1.1 Land Use and Biotic Community Cover Types

Current land use and biotic community cover types were mapped according to the Florida Land Use Cover Classification System (FLUCCS) (1995). GIS files were obtained from the South Florida Water Management District (SFWMD) web site and converted to ArcView format for modification. Field surveys did not identify any discrepancies with existing conditions. Figure 5 presents the FLUCCS category map for the project area, and an index of applicable FLUCCS designations is located in Table 3.

The following sections provide descriptions for the FLUCCS categories within the project boundaries that are considered natural areas and are of resource value or otherwise of note.

3220 Coastal Scrub

This scrub category represents a conglomeration of species found in the coastal zone. A few of the more common components are saw palmetto (*Serenoa repens*), sand live oak (*Quercus geminata*), myrtle oak (*Q. myrtifolia*), yaupon (*Ilex vomitoria*), railroad vine (*Ipomoea pes-caprae*), sea oats (*Uniola paniculata*), sea purslane (*Sesuvium maritimum*), sea grape (*Coccoloba uvifera*), Spanish bayonet (*Yucca aloifolia*), and prickly pear (*Opuntia sp.*). This cover type is generally found in dune and white sand areas. The only coastal scrub habitat located within the project area is within the boundaries of John U. Lloyd State Recreation Area (SRA) and just south of the SRA along the same peninsula.

4220 Brazilian Pepper

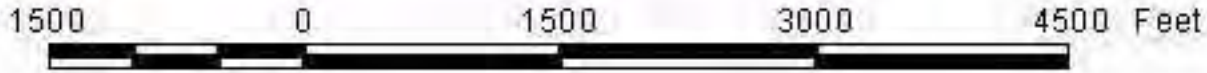
Brazilian pepper (*Schinus terebinthifolius*) an exotic, pestilent, species is found on peninsular Florida from the Tampa area southward. Commonly found on disturbed sites, this native of Brazil is also an aggressive invader of Florida's natural plant communities. Communities of these small, shrub-like trees are often established along borrow pits, levees, dikes, and old disturbed fields. This land cover occurs in scattered locations throughout the project area, with large portions occurring just west of West Lake Park.



LEGEND

Environmental Resource Survey Limits

1995 FLUCCS




1995 Florida Land Use/Cover Classification (FLUCCS)	
Port Everglades Baseline Environmental Resource Survey	
Scale: 1" = 1,500'	Drawn By: MR
Date: May, 2001	Approved By:
 DIAL CORDY AND ASSOCIATES INC. <small>Environmental Consultants</small>	J00-426
	Figure 5

Table 3 Florida Land Use Cover Classification System Categories Within the Project Boundaries

1009	Mobile Home Units Any Density	2510	Horse Farms
1110	Residential, Low Density-Fixed Single Family Units	2610	Fallow Crop Land
1210	Residential, Medium Density-Fixed Single Family Units	3220	Coastal Scrub
1290	Residential, Medium Density-Under Construction	3290	Other Shrub and Brush
1310	Residential, High Density-Fixed Single Family Units	4220	Brazilian Pepper
1340	Residential, High Density-Multiple Dwelling Units, High Rise	4240	Melaleuca
1390	Residential, High Density-Under Construction	4340	Hardwood Conifer Mixed
1410	Retail Sales and Service	4370	Australian Pine
1411	Shopping Centers	4380	Mixed Hardwoods
1430	Professional Services	5100	Streams and Waterways
1450	Tourist Services	5220	Lakes >100 Acres-<500 Acres
1470	Mixed Commercial and Services	5330	Reservoirs >10 Acres-<100 Acres
1480	Cemeteries	5340	Reservoirs <10 Acres
1490	Commercial Services Under Construction	5600	Slough Waters
1550	Other Light Industrial	6120	Mangrove Swamps
1560	Other Heavy Industrial	6170	Mixed Hardwood Wetlands
1710	Educational Facilities	6172	Mixed Hardwood Wetlands-Mixed Shrubs
1720	Religious	6300	Wetland Mixed Forest
1730	Military	6412	Freshwater Marsh – Cattails
1810	Swimming Beach	6430	Wet Prairies
1820	Golf Courses	7100	Beaches Other Than Swimming Beaches
1840	Marinas and Fish Camps	7420	Borrow Areas
1850	Parks and Zoos	7430	Spoil Areas
1860	Community Recreational Facilities	8110	Airports
1870	Stadiums	8140	Roads and Highways
1890	Other Recreational	8150	Port Facilities
1910	Undeveloped Land with Urban Areas	8160	Canals and Locks
1920	Inactive Land with Street Pattern	8180	Auto Parking Facilities
1930	Urban Land in Transition	8310	Electrical Power Facilities
1940	Other Open Land	8320	Electrical Power Transmission Lines
2110	Improved Pastures	8330	Water Treatment Plants
2140	Row Crops	8340	Sewage Treatment
2430	Ornamentals		

4240 Melaleuca

Melaleuca (*Melaleuca quinquenervia*) an exotic tree species occurs in almost pure stands. It is an aggressive competitor; invading and often taking over a site, forming a dense, impenetrable stand. Melaleuca generally is an indicator of a disturbed site. The only melaleuca within the project boundary is located in the extreme northwest corner of the project area.

4370 Australian Pine

Contrary to its name, Australian pine (*Casuarina equisetifolia*) is actually a hardwood. Its name is derived from its needle-like leaves and its characteristic cone-shaped crown structure. Australian pine was introduced to south Florida from Australia and is colonizing northward to the Tampa Bay area. It is common on disturbed sites, forming dense thickets, and is frequently planted as wind breaks and soil stabilizers. Areas of Australian pine are located throughout the project area from John U. Lloyd SRA, along Dania Beach Boulevard in West Lake Park, and along both sides of the AIWW.

4380 Mixed Hardwoods

This is a hardwood community in which no single species or species group appears to achieve a 66% dominance of the canopy. This class of hardwoods includes any combination of large and small hardwood tree species, none of which can be identified as dominating the canopy. The only mixed hardwood within the project boundaries is a small area located at the northwest corner of the I-595 U.S. 1 intersection.

5600 Slough Waters

Sloughs are channels of slow moving water in the coastal marshland. The term also refers to “backwater sloughs,” those narrow, often stagnant bodies of water found near inland rivers. Sloughs are located within John U. Lloyd SRA and West Lake Park.

6120 Mangrove Swamp (Fringing Mangrove Habitat)

This coastal hardwood community is composed of red (*Rhizophora mangle*) and/or black mangroves (*Avicennia germinans*), which is pure and predominant. The major associates include white mangrove (*Languncularia racemosa*), buttonwood (*Conocarpus erectus*), cabbage palm (*Sabal palmetto*), and sea grape. Fringing mangrove represent the largest natural habitat within the project boundaries (Figure 6). They occur along the western edge of John U. Lloyd SRA adjacent to the AIWW, on a section of the eastern edge of Port Everglades adjacent to the AIWW, south of Port Everglades within West Lake Park along the DCC, and extending northward from the DCC into the port property just south of Eller Drive. An isolated mangrove area is also located north of Eller Drive and east of U.S. 1.

6412 Freshwater Marshes-Cattail

This community is characterized by having cattail (*Typha* sp.) as the single dominant (greater than 66% cover) species. A single isolated freshwater cattail area approximately 3.2



LEGEND

- Environmental Resource Survey Limits
- Freshwater Wetland (as mapped by Craze & Thompson)
- Cattail Marsh (3.2 ac.)
- Approximate Wetlands
- Estuarine, Scrub-Shrub, Fringing Mangrove Community

Estimated Wetland Areas

Port Everglades Baseline
Environmental Resource Survey

Scale: 1" = 2,000'

Drawn By: MR

Date: May, 2001

Approved By:



J00-426

Figure 6

acres in size, based on a wetland delineation performed (personal communication, Allan Sosnow, Port Everglades), occurs within the project boundaries (Figure 6). This area is highly disturbed and was most likely used as a disposal area for prior dredging projects, but has since reverted to a jurisdictional freshwater cattail marsh. This wetland is permitted for fill and as such will not be further considered in the impact assessment.

3.1.2 Jurisdictional Wetlands

Jurisdictional wetlands within the boundaries of the project occur as either fringing mangrove habitat, mixed wetland hardwoods, or cattail marsh and are displayed graphically in Figure 6. Descriptions of the jurisdictional wetland areas are provided below.

Fringing Mangrove Habitat

The majority of the jurisdictional wetlands within the project boundaries occur as fringing mangrove habitat. As described in the previous section, red and/or black mangroves, with a number of associated species, dominate this community type. The mangrove community is important for shoreline protection and stabilization in addition to supporting an abundance of marine species.

Fringing mangrove areas are designated in Figure 6. They occur along the western edge of John U. Lloyd SRA adjacent to the AIWW, on a section of the eastern edge of Port Everglades adjacent to the AIWW, south of Port Everglades within West Lake Park along the DCC, and extending northward from the DCC into the port property just south of Eller Drive. An isolated mangrove area is also located north of Eller Drive and east of U.S. 1. Fringing mangrove habitat along the western side of the AICW is comprised of habitat created by the port as mitigation for previously permitted impacts and native areas of mangrove.

Freshwater Marshes-Cattail

A single isolated freshwater cattail area approximately 3.2 acres in size occurs within the boundary of the project area. This area is highly disturbed and was most likely used as a disposal area for prior dredging projects, but has since reverted to a jurisdictional freshwater cattail marsh. This area is already permitted for construction.

3.1.3 Local Areas of Particular Concern

A number of areas currently exist within the project boundaries that require special consideration with regard to natural resources (Figure 7). John U. Lloyd SRA is comprised of 310 acres and lies just east of the AIWW and east of the port. The area is managed by the Florida Division of Recreation and Parks, and has provided recreational opportunities for the public since 1974. Many of the community types within the area are native communities and are highly valued by the resource agencies and the public.



2000 0 2000 4000 Feet

LEGEND

- Environmental Resource Survey Limits
- Conservation/Recreation/Special Areas
- Conservation Area
- John U. Lloyd Recreation Area
- Local Area of Special Concern
- Prior Mitigation Area
- West Lake Park

Local Areas of Particular Concern

Port Everglades Baseline
Environmental Resource Survey

Scale: 1" = 2,000'

Drawn By: MR

Date: May, 2001

Approved By:



DIAL CORDY
AND ASSOCIATES, INC.
DESIGN/ENGINEERING/CONSTRUCTION

J00-426

Figure 7

West Lake Park is located immediately south of the port and the Dania Cutoff Canal. The 1,400-acre West Lake Park is the largest mangrove estuarine habitat remaining in Broward County. The Broward County Board of County Commissioners is the lead agency in managing West Lake Park through a sublease from the Division of Recreation and Parks.

Within the Port Everglades limits, there are a number of areas designated as Previous Mitigated Areas. These mangrove areas are mitigation for previous wetland impacts associated with the Turning Notch Project in the mid-1990s. An additional 23 acres of mangroves were planted along the eastern edge of the AIWW at John U. Lloyd SRA for mitigation associated with the Turning Notch Project, however they were not placed under a conservation easement, as they were on state owned land.

3.2 Marine Resources

This section includes a description and review of the results of the marine resources survey. It outlines the findings of the seagrass community survey, including species occurrence, abundance and density. It also addresses reef and hardbottom community distributions, species profiles and the presence of Essential Fish Habitat (EFH). A summary of field data from 2000 and 2001 is located in Appendix D.

3.2.1 Seagrass Communities

Seagrass habitat cover type, abundance, and density for the study area are described below. Distribution and occurrence observations for the 1999 survey range from approximately 1200 feet north of Port Everglades Inlet south to about 1000 feet south of the DCC and along the DCC to Port Denison (Figure 8) (DC&A 1999). In the 2000 survey, transects were located within the area 1000 feet south of the DCC on the east side of the channel, and on the west, from the DCC south to the Dania Beach Boulevard Bridge to the east shore to the side of the channel 1000 feet south of DCC, and from the side of the channel to the west shore from the DCC south (Figure 9). To field verify whether seagrass occurred in the OEC, as reported by the DPEP staff (Personal Communication January 18, 2001, Steve Higgins, Beach Erosion Administrator Broward County), an integrated video survey was performed within the federal channel (Figure 8).

3.2.1.1 Seagrass Species Frequency of Occurrence, Abundance, and Density

General Occurrence

Marine seagrass species observed within the study area included *Halodule wrightii*, *Halophila decipiens*, and *Halophila johnsonii*. Of the 62 transects surveyed in 1999 and 2000 (Figure 4),



LEGEND

Environmental Resource Survey Limit

Seagrass Distribution

- Halophila johnsonii* (H. johnsonii)
- Halophila decipiens* (H. decipiens)
- Halodule wrightii*
- Syringodium filiforme*
- H. decipiens/H. johnsonii
- H. decipiens/H. johnsonii/H. wrightii



1000 0 1000 2000 Feet

Seagrass Distribution - Northern Portion of Study Area

Port Everglades Base Line
Environmental Resource Survey

Scale: 1" = 1,000'

Drawn By: MR

Date: May, 2001

Approved By:



**DIAL, CORDY
AND ASSOCIATES, INC.**
Environmental Resource Survey

J00-426

Figure 8



LEGEND	
	Environmental Resource Survey Limits
Seagrass Distribution	
	<i>Halodule wrightii</i> (H. wrightii)
	<i>Halodule decipiens</i> (H. decipiens)
	<i>Halodule wrightii</i>
	<i>Syringodium filiforme</i>
	H. decipiens/H. wrightii
	H. decipiens/H. wrightii/H. wrightii



1000 0 1000 2000 Feet

Seagrass Distribution - Southern Portion of Study Area

Port Everglades Baseline
Environmental Resource Survey

Scale: 1" = 1,000'

Drawn By: M.R.

Date: May, 2001

Approved By:



J00-426

Figure 9

marine seagrass species were observed at 28 transects. A summary of occurrence records for each transect where seagrass was found is given in Table 4. DPEP divers documented the occurrence of *H. decipiens* within the OEC (Personal Communication January 18, 2001, Steve Higgins, Beach Erosion Administrator Broward County)). Video surveys within the channel confirmed the presence of isolated patchy beds of *H. decipiens* in 45 feet of water.

Seagrass occurrence within the interior areas consisted of mixed Submerged Aquatic Vegetation (SAV) with *H. decipiens* and *H. wrightii*, mixed SAV with *H. decipiens* and *H. johnsonii*, monospecific beds of *H. johnsonii*, and monospecific beds of *H. decipiens*.

Frequency of Occurrence

H. johnsonii

H. johnsonii occurred within 14 of the 62 transects sampled. Frequency of occurrence values ranged from 0 to 25% with a mean of 11%.

Other species

Halophila decipiens occurred within 20 transects sampled. Frequency of occurrence for *H. decipiens* values ranged between 0 to 67% with a mean of 12%. In comparison, *H. wrightii* had a range of occurrence values between 0 to 24% with a mean of 8% over the study area.

Abundance

Abundance is expressed as a sum of the cover abundance scores divided by the number of quadrats where the specific species was assigned a score. Scores range from 0 to 5, where 1.0 is <5% cover, 2.0 is 5 to 25% cover, 4.0 is 50 to 75% cover, and 5.0 is >75% cover

H. johnsonii

Abundance values for *H. johnsonii* ranged from 0 to 4 for transects sampled. The average abundance for *H. johnsonii* in the Port Everglades area surveyed was 1.1 (< 5% cover). *H. johnsonii* had the highest abundance values of all species over all transects.

Other Species

Cover abundance for *H. wrightii* was low as it only occurred in 8 of the 62 transects sampled. The abundance values ranged from 0.1 to 1.5 with a mean 0.34. *H. decipiens* however, had values for cover abundance in the 0.1 to 5.0 range with a mean of 0.65.

Table 4 Seagrass Frequency of Occurrence, Abundance, and Density Values for Port Everglades Survey Transects for 1999-2000 Survey

		Halodule wrightii	Halophila decipiens	Halophila johnsonii	Halodule wrightii	Halophila decipiens	Halophila johnsonii	Halodule wrightii	Halophila decipiens	Halophila johnsonii
Transect		Frequency of Occurrence			Abundance			Density		
PE99-1	Total		0.0938			0.1000			0.0094	
PE99-2	Total		0.3438			0.1140			0.0391	
PE99-3	Total		0.0156			0.1000			0.0016	
PE99-6	Total		0.0750	0.1375		0.1000	0.1910		0.0075	0.0263
PE99-7	Total			0.1750			0.0790			0.0138
PE99-8	Total		0.0781	0.0469		0.1000	0.0330		0.0078	0.0016
PE99-10	Total		0.0357			0.0250			0.0009	
PE99-12	Total		0.0313	0.1458		0.1000	0.1860		0.0031	0.0271
PE99-13	Total	0.2250		0.1750	0.1110		0.1430	0.0250		0.0250
PE99-14	Total	0.0156	0.0625	0.0313	0.0500	0.0630	0.0500	0.0008	0.0039	0.0016
PE99-15	Total		0.0104	0.0208		0.1000	0.0500		0.0010	0.0010
PE99-17	Total			0.1458			0.1430			0.0208
PE99-24	Total	0.1250			0.1250			0.0156		
PE99-25	Total	0.0625			0.0500			0.0031		
PE99-32	Total			0.2250			0.1940			0.0438
PE99-34	Total			0.2500			0.1590			0.0398
PE99-35	Total			0.0125			0.1000			0.0013
PE99-36	Total		0.0078			0.1000			0.0008	
DCOC-16	Total		0.0313			0.1000			0.0031	
PE00-1	Total		0.4844	0.2500		0.0970	0.2500		0.0469	0.0600
PE00-2	Total	0.2411	0.6696		0.0930	0.2270		0.0223	0.1518	
PE00-3	Total		0.1719			0.1820			0.1563	
PE00-4	Total		0.5000			0.3130			0.1563	
PE00-5	Total	0.0469	0.2031	0.0156	0.1000	0.1540	0.1880	0.0469	0.0313	0.0469
PE00-6	Total		0.3906			0.2000			0.0781	
PE00-7	Total		0.2083			0.1000			0.0208	
PE00-8	Total	0.0313	0.0313		0.2500	0.5000		0.0078	0.0156	
PE00-9	Total	0.1667	0.4896	0.1354	0.2500	0.1380	0.3080	0.1667	0.0677	0.0417

Density

Density is expressed as the sum of the cover abundance scores divided by the total quadrats sampled. When compared to abundance values, density values are very low compared to abundance because values are averaged across all quadrats within each transect, rather than only at occupied quadrats.

H. johnsonii

Density for this species was the highest of all species in the study area, with values not exceeding an average value of 0.3242 per meter squared. The range of density values for *H. johnsonii* was 0 to 1.0.

Other Species

Halophila decipiens had the second highest density values encountered, with a range of 0.0125 to 2.5 with an average of 0.3193. *H. wrightii* had the lowest densities of the three species with values ranging from 0 to 0.75 with a mean of 0.1519.

3.2.1.2 Associated Marine Plants and Animals

Seagrass communities provide important habitat for many different species of flora and fauna. In particular, the seagrass communities of southeastern Florida have a host of other flora that live within the seagrass community. These include, but are not limited to, algae of the genera *Halimeda*, *Udotea*, and *Penicillus* (Zieman 1982). Many invertebrate species also utilize seagrass communities. The most obvious inhabitants include the queen conch (*Strombus gigas*), urchins including the long spine urchin (*Diadema antillarum*), nudibranchs, bivalve mollusks, and crustaceans including the spiny lobster (*Panularis argus*), and the blue crab (*Callinectes sapidus*). On shallow seagrass areas corals and sponges may also occur (Zieman 1982). Many fish species have also been shown to have life cycles dependent on seagrass beds. Of particular importance are the mullet (*Mugil cephalus*), snook (*Centropomus undecimalis*), and many prey species including mojarras and pinfish. Seagrass beds are also important nurseries for many of the fish associated with SAFMS Snapper-Grouper Complex (SAFMC 1998).

3.2.2 Hardbottom and Reef Communities

This section outlines the hardbottom and reef communities located offshore of John U. Lloyd SRA and the study area north, south and within the Outer Entrance Channel.

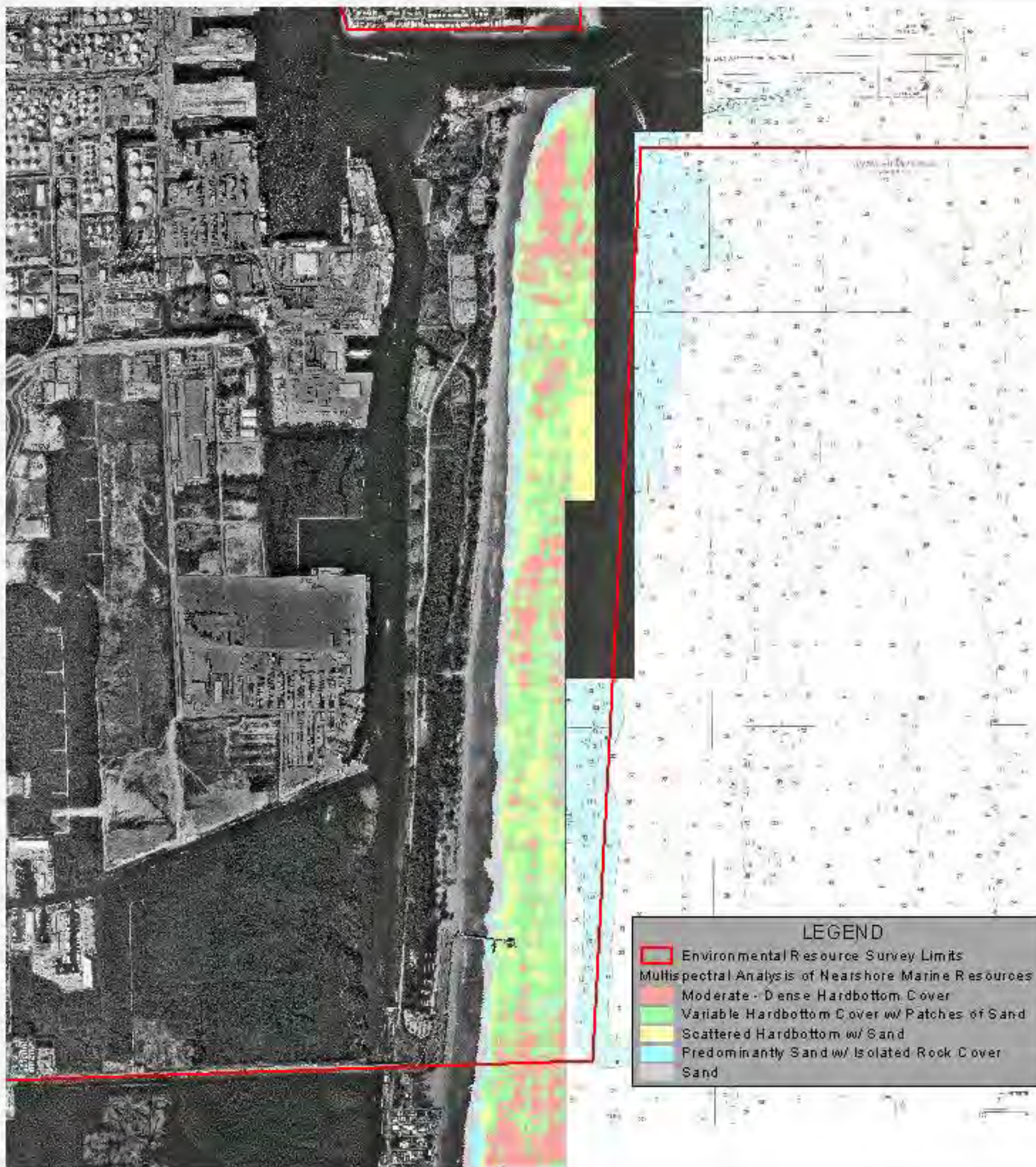
3.2.2.1 Hardbottom and Reef Distribution

The nearshore hardbottom communities typically occur in 0 to 10 feet of water and exist in a physically stressed environment. This hardbottom area is part of the Miami Oolite Formation of Broward and Dade Counties (Hoffmeister et al. 1967). Hardbottom areas in Broward County run inside the nearshore reef tract, and are exposed where wave action has exposed the oolite formations. Nearshore hardbottom areas offshore of John U. Lloyd SRA has been characterized using multi-spectral image analysis classification. The resulting classification is shown in Figure 10. Ground truthing of these nearshore hardbottom areas was performed on May 16-17, 2001. These hardbottom areas are comprised of exposed rock with a fine covering of sand. These oolitic limestone formations are covered with communities dominated by algae and sponges with interspersed gorgonians and hard corals.

Seaward of the nearshore hardbottom area there are three separate parallel reef tracts. The first reef occurs from approximately 100 to 2000 feet from shore; the second reef is located 3,000 to 6,000 feet offshore; and the third reef is approximately 8,000 feet or more offshore (USACE 1996). There is an extensive sand area located between the second and third reef lines (USACE 1996). The area between the first and second reef lines is characterized by small isolated hermatypic coral heads and interspersed coral rubble, with areas of open sand.

The Coast of Florida Study (USACE 1992) maps show reef resources located within the entrance channel and adjacent areas. Transects swum by divers from DPEP Marine Resources Division indicate that no reef is located in the channel in this area, rather the area consists of scattered hardbottom consisting of rock outcroppings (Personal Communication January 18, 2001, Steve Higgins, Beach Erosion Administrator Broward County). Early mapping efforts associated with this study showed the previous resource maps are skewed an unknown amount and that they should not be considered reliable. A more thorough mapping of the marine resources within the Entrance Channel and the surrounding area was conducted on May 16-17, 2001 to clearly define the type and quality of habitat present.

Based on the integrated video mapping survey conducted in May 2001, marine resources in the study area were reclassified and a resource mosaic prepared (Figure 11). Resources within the OEC included sand, low-relief reef, high relief reef, scattered rock/rubble, and patchy sparse *H. decipiens*. The area of low-relief hardbottom in water greater than 42 feet is a viable community with both gorgonians and hard corals present. This habitat is not of the same quality as areas of hardbottom outside of the channel due to the disturbed nature of the area. This area of low-relief hardbottom is rock exposed from prior dredging events and re-colonized after dredging. This community is comprised mostly of fast colonizing species such as sponges (e.g. *Ircinia* sp., *Niphates* sp., *Cliona* sp., and *Iotrochota* sp.) and gorgonians (e.g. *Eunicea* sp., *Plexaura* sp. and *Pseudopterogorgia* sp) and these communities can be expected to colonize these areas after any future dredging events.



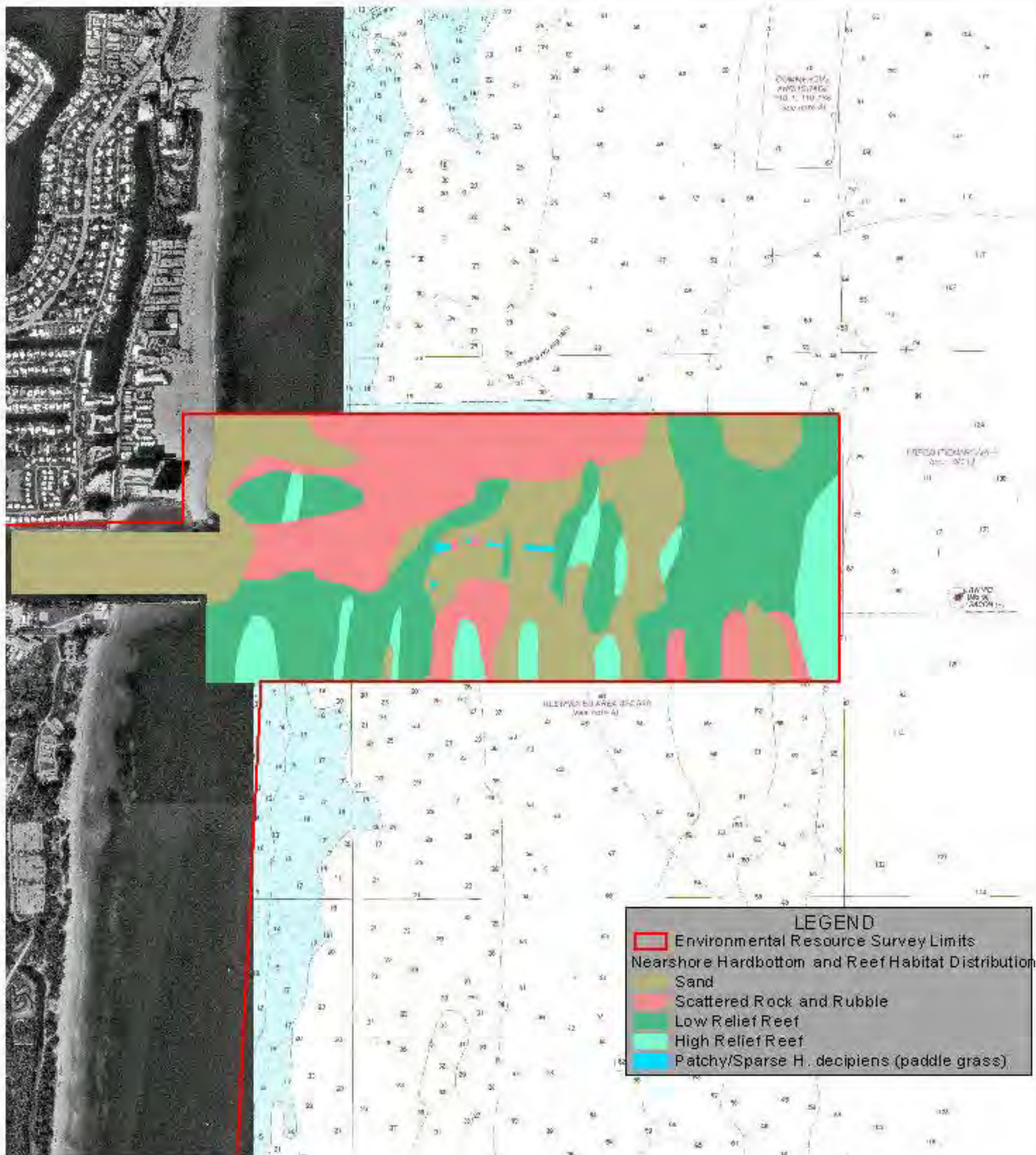
LEGEND

- Environmental Resource Survey Limits
- Multispectral Analysis of Nearshore Marine Resources
- Moderate - Dense Hardbottom Cover
- Variable Hardbottom Cover w/ Patches of Sand
- Scattered Hardbottom w/ Sand
- Predominantly Sand w/ Isolated Rock Cover
- Sand


2000 0 2000 4000 Feet



Nearshore Marine Resource Cover Map	
Port Everglades Baseline Environmental Resource Survey	
Scale: 1" = 2,000'	Drawn By: MR
Date: May, 2001	Approved By:
 DIAL-CORBY AND ASSOCIATES INC. <small>Marine Surveyors & Scientists</small>	JDD-426
	Figure 1D



1500 0 1500 3000 Feet

Hardbottom and Reef Habitat Distribution	
Port Everglades Baseline Environmental Resource Survey	
Scale: 1" = 1,500'	Drawn By: MR
Date: May, 2001	Approved By:
 DIAL-CORBY AND ASSOCIATES INC. <small>PLANNING • DESIGN • CONSTRUCTION</small>	JDD-426
	Figure 11

3.2.2.1.1 Algae and Invertebrates Associated with Hardbottom and Reef Habitats

Live hardbottom and reef communities located in the study area have a great deal of diversity in the numbers of species present. These hardbottom communities have been characterized many times in the past (Dodge 1991; Seaman 1985; Britt 1977). The nearshore hardbottom occurs typically in 0 to 10 feet of water and is exposed to wave action, sediment transport, and varied water clarity. This habitat is very ephemeral in nature and the species associated with this habitat must be able to quickly recover from the stresses imposed by the environmental conditions. The dominant algae associated with these communities are in the genera *Caulerpa* sp., *Jania* sp., *Laurencia* sp., *Dictyota* sp. and *Halimeda* sp. (Dodge 1991, Vare 1991). Also associated with this nearshore hardbottom are algal mat species of the genus *Cladophora* sp., *Chaetomorpha* sp., and *Gelidiopsis* sp. (USACE 2000). The rock outcrops in this area tend to be covered with sponges of the genera *Ircinia* sp., *Niphates* sp., *Cliona* sp., and *Iotrochota* sp. Interspersed among these sponges are colonial anemones (*Zoanthus* sp.), and hydrocorals (*Millepora alcicornis*). This habitat often provides suitable habitat for a variety of other invertebrate species. (USACE 2000)

The most dominant feature of the reef communities near Port Everglades is the high density of gorgonians. These gorgonian corals are primarily of the genus *Eunicea* sp., *Plexaura* sp. and *Pseudopterogorgia* sp. Hard coral species also make up a significant part of the reef assemblages in this area and include *Porites asteroides*, *Diploria clivosa*, *Siderastrea siderea*, and *Montastrea cavernosa* (Britt 1977; Dodge 1991; Vare 1991). Representative photographs of the reef tracts from the reef surveys and video surveys are shown in Appendix C. The three distinct reef tracts offshore of Broward County are consistent with the overall assemblage of stony corals, sponges, and gorgonians found throughout Dade, Broward, and Palm Beach Counties (USACE 2000).

3.2.2.1.2 Visual Fish Survey

A visual fish survey at nearshore hardbottom and offshore reef sites was conducted along transects within the jetty of the entrance channel, hardbottom and offshore sites. The results of these surveys are shown in Table 5. Fish species encountered within the entrance channel to Port Everglades consisted primarily of members of the Family Pomacentridae (damselfishes) and Labridae (wrasses). Also abundant were juvenile Haemulid (grunt) and Lutjanid (snapper) species. These fishes, particularly the Lutjanid species, are important due to their potential recreational and commercial value and are included in the SAFMC Snapper-Grouper Complex. In total over 22 species of fish were recorded within the jetty of the entrance channel.

The nearshore hardbottom area had only 10 species of fish observed, the least of the habitats sampled. Once again the Labrids and Pomacentrids were the dominant species present, while Scarids (parrotfishes) and Acanthurids (surgeonfishes) were also commonly seen. Within this habitat, the yellowtail snapper (*Ocyurus chrysurus*) was also observed. Other species of fish

Table 5 Relative Abundance of Fish Species Observed During Visual Survey Port Everglades, Florida

Common Name	Scientific Name	Channel	Hard Bottom	Offshore Reef
Bluehead Wrasse	<i>Thalassoma bifasciatum</i>	A	C	C
Slippery Dick	<i>Halichoeres bivittatus</i>	A	C	C
Yellowhead Wrasse	<i>Halichoeres garnoti</i>	-	-	C
Sergeant Major	<i>Abudefduf saxailis</i>	A	C	-
Cocoa Damselfish	<i>Pomacentrus variabilis</i>	A	C	A
Beaugregory	<i>Pomacentrus partitus</i>	A	-	A
Dusky Damselfish	<i>Pomacentrus fuscus</i>	C	-	C
Bar Jack	<i>Caranx ruber</i>	O	-	O
Princess parrotfish	<i>Scarus guacamaia</i>	O	C	O
Stoplight parrotfish	<i>Sparisoma viride</i>	O	C	O
Spottail Pinfish	<i>Diplodus holbrooki</i>	C	-	-
Hairy Blenny	<i>Labrisomus nuchipinnis</i>	R	-	-
Highhat	<i>Equetus acuminatus</i>	R	-	-
Sheepshead	<i>Archosargus probatocephalus</i>	R	-	-
Ocean surgeon	<i>Acanthurus bahianus</i>	C	C	C
Blue Tang	<i>Acanthurus coeruleus</i>	C	C	C
Spanish Mackerel	<i>Scomberomorus maculatus</i>	-	-	O
Sharpnose Puffer	<i>Canthigaster rostrata</i>	R	-	R
Checkered Puffer	<i>Sphoeroides tetudineus</i>	R	-	-
Bermuda Chub	<i>Kyphosus sectatrix</i>	O	-	-
Green Moray	<i>Gymnothorax funebris</i>	R	-	-
Purplemouth Moray	<i>Gymnothorax vicinus</i>	-	-	R
French Angelfish	<i>Pomacanthus paru</i>	O	-	O
Grey Angelfish	<i>Pomacanthus arcuatus</i>	O	-	O
Queen Angelfish	<i>Holocanthus ciliaris</i>	O	-	O
Rock Beauty	<i>Holocanthus tricolor</i>	-	-	O
Reef Butterflyfish	<i>Chaetodon sedentarius</i>	-	-	O
Foureye Butterflyfish	<i>Chaetodon capistratus</i>	-	-	O
Spotfin Butterflyfish	<i>Chaetodon ocellatus</i>	-	-	O
Porkfish	<i>Anisotremus virginicus</i>	-	-	O
Tobaccofish	<i>Serranus tabacarius</i>	-	-	O
Harlequin Bass	<i>Serranus tigrinus</i>	-	-	O
Hogfish	<i>Lachnolaimus maximus</i>	-	-	O
Red Grouper	<i>Epinephelus morio</i>	-	-	O
Bluestripe Grunt	<i>Haemulon sciurus</i>	-	-	O
French Grunt	<i>Haemulon f lavolineatum</i>	-	-	O
Juvenile Grunts	<i>Haemulon spp</i>	A	-	-
Juvenile Snapper	<i>Lutjanus spp</i>	A	-	-
Yellowtail Snapper	<i>Ocyurus chysurus</i>	-	O	O
Hamlet	<i>Hypoplectrus unicolor</i>	-	-	O
Scrawled Cowfish	<i>Lactophyrus quadricomis</i>	-	-	O
Gray Triggerfish	<i>Balistes capricus</i>	-	-	O
Blenny	<i>Malacoctenus spp.</i>	-	O	O
Yellow Stingray	<i>Urolophus jamaicensis</i>	-	-	O
Yellowhead Jawfish	<i>Opistognathus aurifrons</i>	-	-	R
Spotted Goatfish	<i>Pseudopeneus maculatus</i>	-	-	O

that use this nearshore hardbottom area include bar jacks (*Caranx ruber*), hogfish (*Lachnolaimus maximus*), and porkfish (*Anistroremus virginicus*), as well as many others (Coastal Systems International 1997).

The offshore coral reef areas observed had the highest number of fishes encountered, with 36 species observed. Once again the most abundant species encountered were wrasses and damselfish. The bluehead wrasse (*Thalasomma bifasciatum*), cocoa damselfish (*Pomacentrus variabilis*) and the beaugregory damsel (*Pomacentrus partitus*) were among the most common. This concurs with similar findings by Spieler (1998). Of particular interest, juvenile red grouper (*Epinephelus morio*), yellowtail snapper (*Ocyurus chysurus*), Spanish mackerel (*Scomberomorus maculatus*), and grunts (Haemulidae), were recorded within these offshore reef habitats. All of these species are listed in the SAFMC management plan (1998).

3.2.3 Unvegetated Bottom Communities

The shallow unvegetated communities of the AIWW and basins associated with Port Everglades have been extensively surveyed in relation to monitoring of past maintenance dredging within the port area. This area consists of softbottom benthic communities interspersed with rubble left from previous dredging activities. Messing and Dodge (1997) and Rudolph (1986) have identified as many as 370 species of invertebrates within the shallow water benthic community. The most consistent fauna within these communities consist of several taxa of polychaete worms, oligochaetes, mollusks, sipunculans, peracarid crustaceans, platyhelminthes, and nemertina (Messing and Dodge 1997, Rudolph 1986). All of these studies were conducted in shallower areas adjacent to the existing channel or turning basin, and reflect a more diverse and abundant benthic community than likely occurs in the deeper federal channel or waterways of the Port.

In offshore softbottom communities the most dominant organisms tend to be polychaete and nematode worms. Dodge (1991) found during an infaunal study offshore of Hollywood Beach that the dominant taxa were polychaetes (52%), nematodes (14%), and crustaceans (9%). Macroalgal growth is also associated with these communities with the most abundant species being from the green algae genera *Caulerpa* sp., *Halimeda* sp., and *Codium* sp. during the summer months. This is in contrast to the winter months where *Dictyota* sp. and *Sargassum* sp. are more common (USACE 1996). Invertebrate fauna also utilize this softbottom area and these can include the Florida fighting conch (*Strombus alatus*), milk conch (*Strombus costatus*), king helmet (*Cassia tuberosa*), and the queen helmet (*Cassia madagascariensis*) (USACE 1996). This area, since it lies within the second and third reef lines within the study area, may provide a corridor for reef species to travel between reef lines and also be an important foraging area for some fish species (Jones, et al. 1991).

3.2.4 Essential Fish Habitat

The SAFMC (1998) has designated that mangrove, seagrass, nearshore hardbottom, and offshore reef areas within the study area as EFH (Table 6). The nearshore bottom and offshore reef habitats of southeastern Florida have also been designated as EFH-HAPC (SAFMC 1998). Managed species that commonly inhabit the study area include Pink shrimp (*Penaeus duorarum*), and spiny lobster (*Panularis argus*). These shellfish utilize both the inshore and offshore habitats within the study area. Members of the 73 species Snapper-Grouper Complex that commonly use the inshore habitats for part of their life cycle include blue stripe grunts (*Haemulon sciurus*), French grunts (*Haemulon flavolineatum*), mahogany snapper (*Lutjanus mahogoni*), yellowtail snapper (*Ocyurus chysurus*), and red grouper (*Epinephelus morio*). These species utilize the inshore habitats as juveniles and sub-adults and as adults utilize the hardbottom and reef communities offshore. In the offshore habitats, the number of species within the Snapper-Grouper Complex that may be encountered increases. Other species of the Snapper-Grouper Complex commonly seen offshore in the study area include gray triggerfish (*Balistes capriscus*), and hogfish (*Lachnolaimus maximus*). Coastal migratory pelagic species also commonly utilize the offshore area adjacent to the study area. In particular, the king mackerel (*Scomberomorus cavalla*), and the Spanish mackerel (*Scomberomorus maculatus*) are the most common. As many as 60 corals can occur off the coast of Florida (SAFMC 1998) and all of these fall under the protection of the management plan.

3.3 Threatened and Endangered Species

A number of state and federally listed protected species occur in south Florida and Broward County. A list of protected flora and fauna for Broward County was obtained from the Florida Natural Areas Inventory (FNAI) and is included in Appendix B. Descriptions of terrestrial and marine protected species, which are known to occur within the study area, are provided in the following sections.

3.3.1 Terrestrial Species

Utilization of the terrestrial habitats within the project area by protected species is limited due to the highly urbanized nature of the region. Listed flora such as the golden leather fern (*Acrostichum aureum*) occur in the fringing areas of mangrove swamps and along various watercourses, while other listed plant species such as sea lavender (*Argusia gnaphalodes*) and beach peanut (*Okenia hypogaea*) occur in the dune areas and estuarine habitats on John U. Lloyd SRA. These plants are listed by the Florida Department of Agriculture, but have no federal status. Coordination with the state will not be required concerning these species.

A number of listed and migratory bird species utilize the area and surrounding waters for feeding, loafing, and roosting. A complete listing of these species is located in Appendix E. No other terrestrial listed species or their habitats were identified within the project boundaries.

Table 6 Essential Fish Habitat Areas in South Florida

Estuarine Areas (Dania Cut-Off Canal, AIWW, Inner Entrance Channel)	Estuarine Emergent Vegetation
	Estuarine shrub/scrub (mangrove)
	Seagrass
	Intertidal flats
	Estuarine Water Column
Marine Areas (Outer Entrance Channel, Nearshore and Off-shore areas)	Live/Hard Bottom
	Coral and Coral Reef
	Artificial Reefs
	Sargassum
	Water Column

Source: South Atlantic Fisheries Management Council, 1998

3.3.2 Marine Species

A description of the threatened and endangered marine species known to occur in the study area is outlined in this section. Distribution within the study area, and seasonal occurrences are discussed (Figure 12).

3.3.2.1 *H. johnsonii*

H. johnsonii was listed as a threatened species by NMFS on September 14, 1998 (63 FR 49035) and a re-proposal to designate critical habitat pursuant to Section 4 of the Endangered Species Act (ESA) was published on December 2, 1998 (64 FR 64231). The final rule for critical habitat designation for *H. johnsonii* was published 5 April 2000 (Federal Register, vol. 65, No. 66). *H. johnsonii* has one of the most limited geographic ranges of all seagrass species. It is only known to occur between Sebastian Inlet and northern Biscayne Bay on the east coast of Florida (Kenworthy 1997). As stated in earlier reports (DC&A 1999) and the findings of this survey, *H. johnsonii* occurs within the AIWW south of the turning basin for Port Everglades, in the DCC, and within the area considered for widening and deepening.

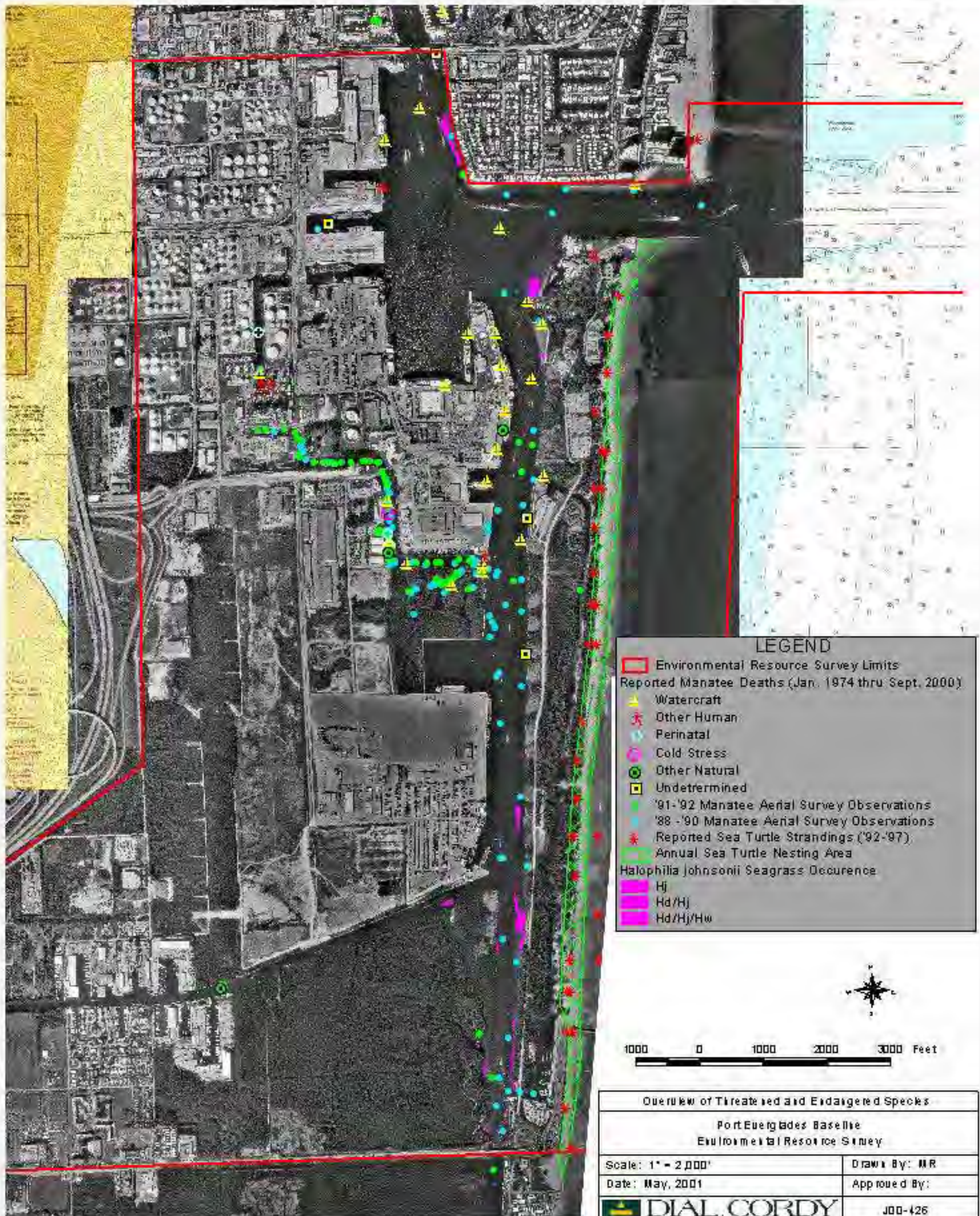
3.3.2.2 *Manatee*

The West Indian manatee (*Trichechus manatus*) has been listed as a protected mammal in Florida since 1893. Federal law under the Marine Mammal Protection Act of 1972 and the Endangered Species Act as amended in 1973 protects manatees. Florida provided further protection in 1978 by passing the Florida Marine Sanctuary Act designating the state as a manatee sanctuary and providing signage and speed zones in Florida's waterways.

Within Broward County there exists both a permanent and transient population of manatees. Surveys show that during the winter months when temperatures drop, manatees from the north Florida and also Dade County will migrate to the Florida Power and Light (FP&L) power plant at Port Everglades (Sirenia Project 2000). During cold weather as many as 234 manatees have been recorded at the Port Everglades plant at one time (Broward County 1992). During the summer months when the water warms, manatees return to the counties to the north and south to forage and reproduce, however, telemetry and aerial surveys confirm manatees are present within Broward County all year (Broward County 1992) (Sirenia Project, 2000) (Figure 12).

3.3.2.3 *Sea Turtles*

Broward County is within the normal nesting range of three species of sea turtles: the loggerhead (*Caretta caretta*), the green sea turtle (*Chelonia mydas*), and the leatherback (*Dermochelys coriacea*). The green sea turtle and leatherback sea turtle are both listed under



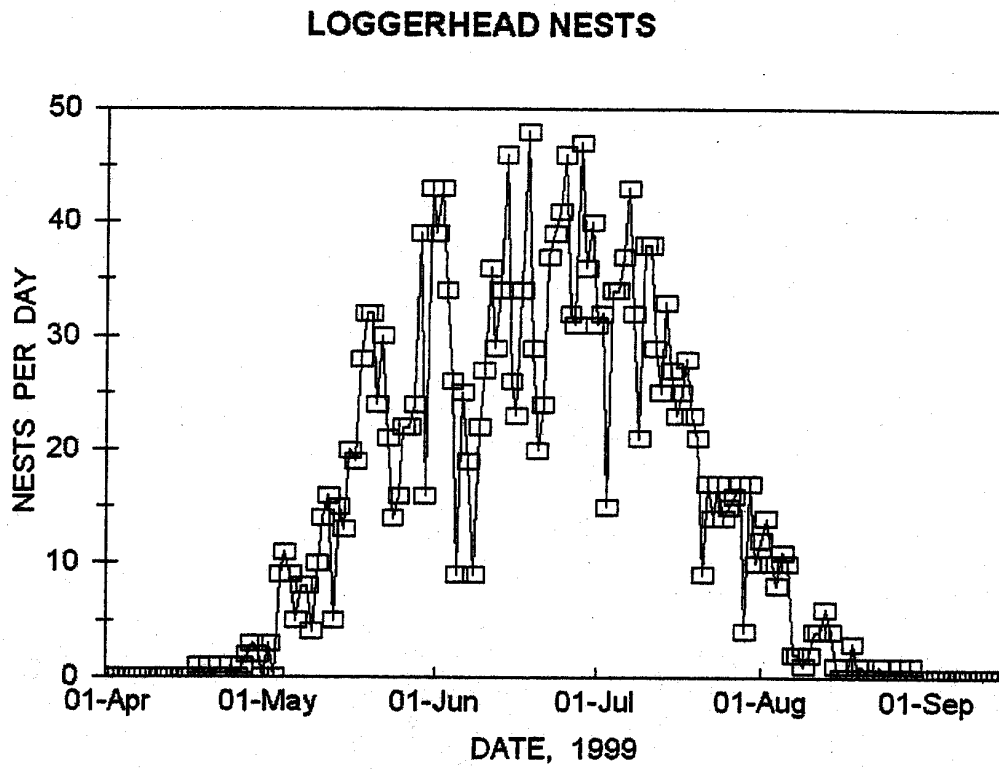
the U. S. Endangered Species Act, 1973 and Chapter 370, F.S. The loggerhead turtle is listed as a threatened species (Burney and Margolis 1999). Within the 38.6 miles of beach from the Palm Beach County line to the Dade County line a total of 2620 sea turtle nests were found in 1999 (Burney and Margolis 1999). From 1990 through 1999, an average of 2446 sea turtle nests were discovered on Broward County beaches. Within John U. Lloyd SRA a total of 212 sea turtle nests were observed during 1999. A summary of sea turtle nesting activity for John U. Lloyd SRA is found in Table 7. The majority of sea turtle nesting activity occurred during the summer months of June, July and August, with nesting activity occurring as early as March and as late as September (Burney and Margolis 1999) (Figure 13). Figure 14 represents the historical nesting success of turtles on Broward County beaches from 1991 through 1999. The waters offshore of Broward County are also habitat used for foraging and shelter for the three species listed above and possibly the hawksbill turtle (*Eretmochelys imbricata*), and the Kemp's ridley turtle (*Lepidochelys kempii*) (USACE 2000).

Table 7 Summary of Sea Turtle Nesting for John U. Lloyd SRA, 1994-1999

Total Nests	1994	1995	1996	1997	1998	1999
Loggerheads	190	248	206	181	253	210
Greens	14	10	18	5	21	2
Leatherbacks	1	0	0	2	3	0

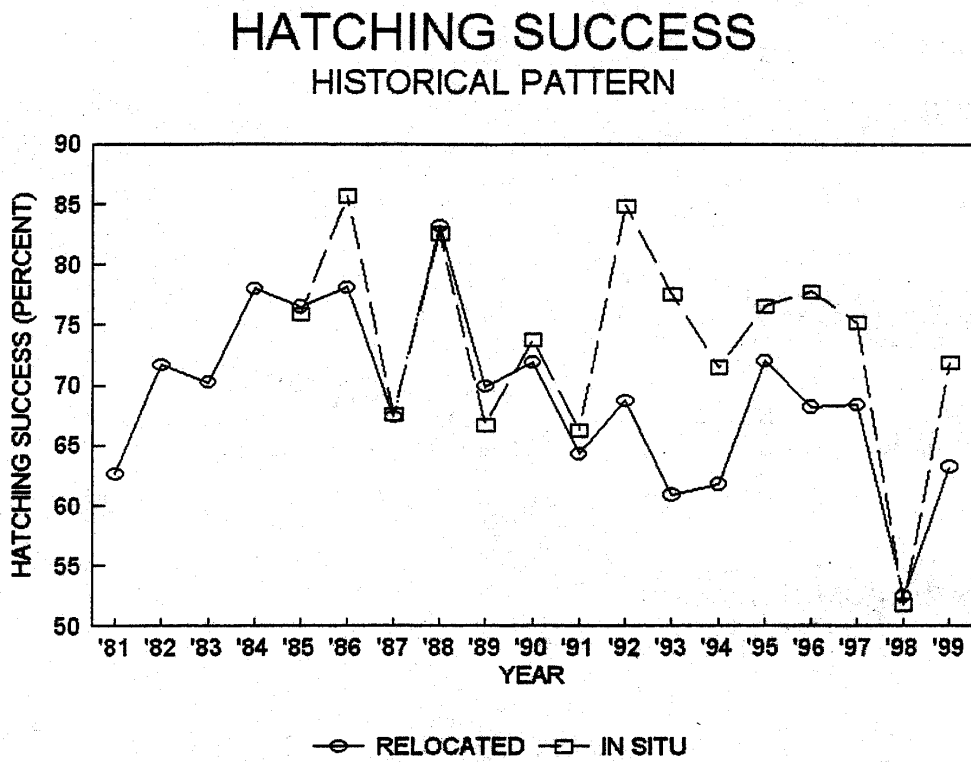
Source: Burney and Margolis, 1994-1999

Figure 13 Seasonal Pattern of Daily Loggerhead Nesting in Broward County, 1999



Source: Broward County Department of Natural Resource Protection, Technical Report 00-01. Sea Turtle Conservation Report 1999.

Figure 14 Historical Patterns of Yearly Hatchling Success for All Evaluated In-Situ and Relocated Sea Turtle Nests Since 1981



Source: Broward County Department of Natural Resources Protection
Technical Report 00-01. Sea Turtle Conservation Report 1999.

4.0 IMPACT ASSESSMENT

This section describes the impacts of the proposed Study Elements and their Alternatives on terrestrial, wetland, and marine resources, as well as, threatened and endangered species. The analysis of direct impacts includes the immediate land area of the sites affected, and marine areas directly affected by, dredging, construction, and related activities (Table 8, and Figures 15, 16, 17, 18, 19, 20, 21). The analysis of indirect impacts includes the potential impacts related to these activities on the habitats directly adjacent to the areas proposed for expansion or upon marine mammals and fish within the water column (Table 8). An assessment of the direct, indirect, and cumulative impacts of the combined study elements cannot be determined until the recommended plan has been selected.

4.1 Alternatives S-1A, S1-B

Alternatives S-1A and S-1B entail the widening and deepening of the SAC including deepening of the OEC, IEC, MTB and removal of the widener shoal (Table 8). The alternatives differ in that S-1A includes the construction of a bulkhead along John U. Lloyd SRA, while S-1B includes the construction of a side-slope along John U. Lloyd SRA (Figures 15 and 16). The maximum depth being analyzed will be 58 feet in the OEC.

4.1.1 Impacts to Terrestrial Resources

Alternatives S-1A and S-1B would directly impact mangrove wetlands within the project boundaries. Approximately 2.34 acres of mangrove habitat along the western boundary of John U. Lloyd SRA extending from just south of the existing boat ramp northward to south of Nova University would be removed with the channel widening with alternative S-1A. Although a bulkhead would constitute the western portion of the channel, some impact to the mangrove habitat would still be required.

Alternative S-1B would differ from Alternative S-1A in that the eastern edge of the channel would be constructed with a side slope rather than bulkhead. Alternative S-1B would result in approximately 4.19 acres of impact to mangrove wetlands along the same corridor as Alternative S-1A, although the impact area would extend an additional 137 linear feet into John U. Lloyd SRA (Table 8) (Figures 15 and 16). Other SRA facilities that could be affected by this alternative include the existing boat ramp parking and an outdoor classroom facility west of the public beach parking area.

Table 8 Impact Acreages by Habitat Type

	Footprint Area	Terrestrial Habitat Types		Marine Habitat Types								
		Upland Acres	Wetland (Mangrove) Acres	Seagrass Out Channel	Seagrass In Channel	Scattered Rock/ Rubble In Channel	Scattered Rock/ Rubble Out of Channel	Low-Relief Reef In Channel	Low-Relief Reef Out of Channel	High Relief Reef In Channel	High Relief Reef Out of Channel	Unvegetated Bottom Acres
Study Element 1												
S-1A	283.51	0.28	2.34	0.62	1.47	16.10	0	11.47	2.15	3.13	0.73	245.22
S-1B	305.91	5.02	4.19	2.04	1.35	16.10	0	11.47	2.15	3.13	0.73	259.73
Study Element 5												
S-5A	36.63	9.35	2.01	0.66	0	0	0	0	0	0	0	24.61
S-5B	43.76	15.06	3.28	0.69	0	0	0	0	0	0	0	24.60
Study Element 6												
S-6A	42.24	0	18.82	0.69	0	0	0	0	0	0	0	22.73
S-6B	50.01	0	25.56	0.68	0	0	0	0	0	0	0	23.77
Study Element 7												
S-7	13.37	0	0	0	0	0	0	0	0	0	0	13.37
Study Element 8												
S-8	19.74	0	0	0	0	0	0	0	0	0	0	19.74
Study Element 9												
S-9	32.32	1.83	8.48	0	0	0	0	0	0	0	0	22.01

Note: Acreages established by overlaying project plans over known natural resource polygons using ArcView.



1500 0 1500 3000 Feet



S-1A Project Footprint and Associated Impacts

Port Everglades Base Line
Environmental Resource Study

Scale: 1" = 1,500'

Drawn By: M.R.

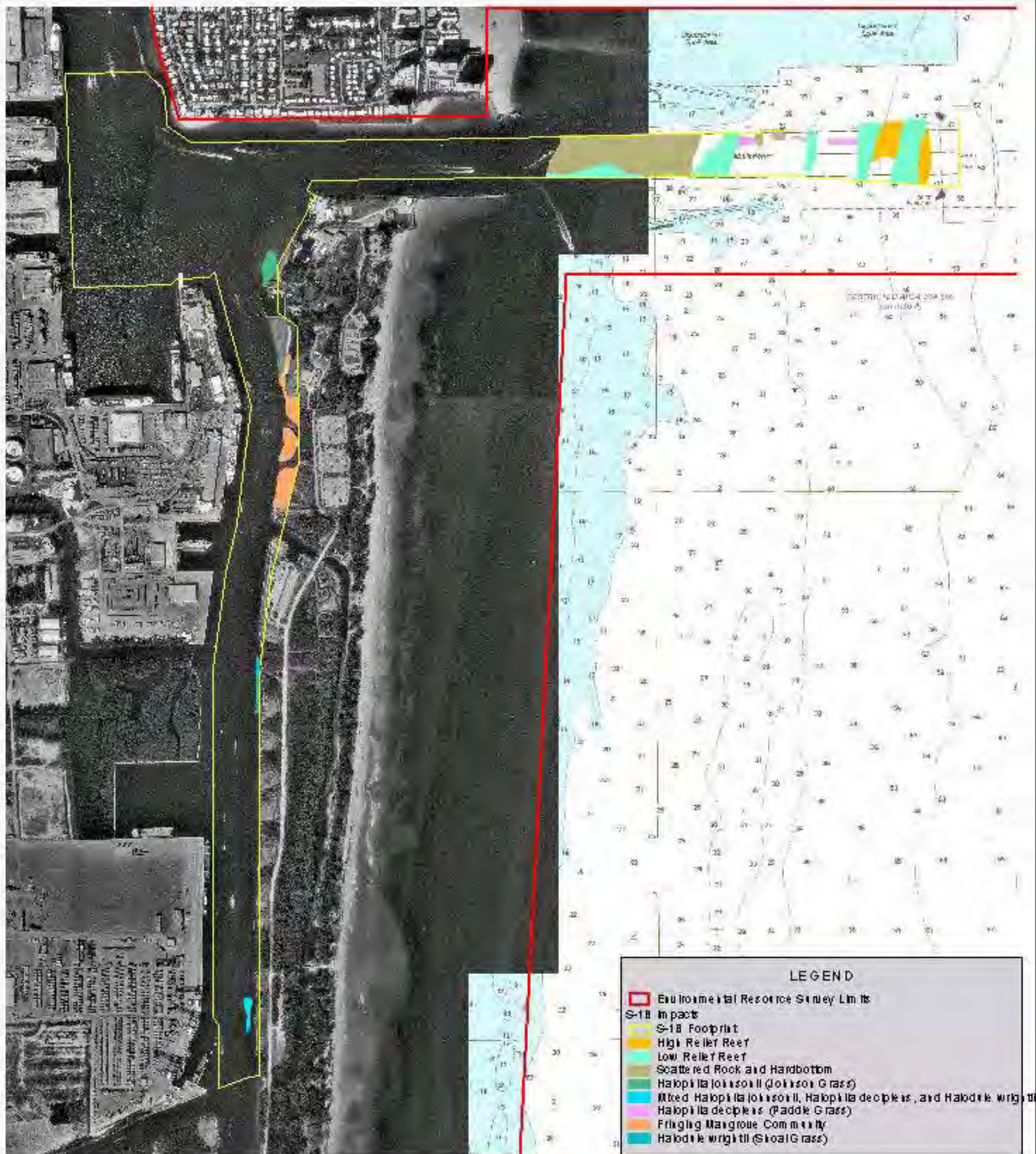
Date: May, 2001

Approved By:



JDD-426

Figure 15



1500 0 1500 3000 Feet



S-18 Project Footprint and Associated Impacts

Port Everglades Base Line
Environmental Resource Survey

Scale: 1" = 1,500'

Drawn By: M.R.

Date: May, 2001

Approved By:



JDD-426

Figure 16



1000 0 1000 2000 3000 Feet



S-5A Project Footprint and Associated Impacts

Port Everglades Base Line
Environmental Resource Survey

Scale: 1" = 1,000'

Drawn By: M.R.

Date: May, 2001

Approved By:



J00-426

Figure 17



1000 0 1000 2000 3000 Feet



S-58 Project Footprint and Associated Impact	
Port Everglades Base line Environmental Resource Study	
Scale: 1" = 1,000'	Drawn By: M.R.
Date: May, 2001	Approved By:
 DIAL & CORBY AND ASSOCIATES INC. <small>Environmental Consultants</small>	JDD-426
	Figure 18



1000 0 1000 2000 3000 Feet



S-6A Project Footprint and Associated Impacts

Port Everglades Base Line
Environmental Resource Study

Scale: 1" = 1,000'

Drawn By: M.R.

Date: May, 2001

Approved By:



JDD-426

Figure 19



1000 0 1000 2000 3000 Feet



S-6B Project Footprint and Associated Impacts

Port Everglades Base Line
Environmental Resource Study

Scale: 1" = 1,000'

Drawn By: M.R.

Date: May, 2001

Approved By:



J00-426

Figure 20



LEGEND

- Environmental Resource Survey Limits
- S-8 Impact
- S-8 Footprint
- Fringing Mangrove Community
- S-8 Impact
- S-8 Footprint
- S-7 Impact
- S-7 Footprint



1500 0 1500 3000 4500 Feet

S-7, S-8, and S-9 Project Footprints and Associated Impacts

Port Everglades Base Line
Environmental Resource Study

Scale: 1" = 1,500'

Drawn By: M.R.

Date: May, 2001

Approved By:



JDD-426

Figure 21

4.1.2 Impacts to Marine Resources

This section evaluates the potential direct and indirect impacts of the proposed modification of Alternatives S-1A and S-1B on the marine resources of the Port Everglades area as described in Section 3.3 and Table 8. The direct impacts to marine resources are based upon the area of habitat affected by the proposed modification (i.e. acres dredged, filled). Indirect impacts are those impacts that may potentially affect nearby habitats or communities and may be long-term or temporary in duration.

4.1.2.1 Impacts to Seagrass

There will be direct and indirect impacts to seagrass habitats along the eastern edge of the AICWW and widener shoal, and within the Outer Entrance Channel for both Alternatives S-1A and S-1B (Figure 15 and 16). These impacts will be both long-term and temporary and will impact the endangered marine seagrass species *H. johnsonii*.

4.1.2.1.1 Direct Impacts

Direct impacts to seagrass as a result of either Alternative S-1A or S-1B include the removal of seagrass habitat along the AIWW and the widener shoal during dredging activities. Alternative S-1A will impact 0.62 acres of seagrass habitat outside of the channel and 1.47 acres within the channel, while the creation of the side-slope with Alternative S-1B will result in 2.04 acres of impact outside the channel and 1.35 acres within the channel. Alteration of seagrass habitat will result from the dredging associated with deepening and widening, and also from the creation of either a bulkhead with Alternative S-1A, or a the sideslope with Alternative S-1B. The species affected include *H. johnsonii*, *H. decipiens*, and *H. wrightii*. These seagrass beds are very patchy and have cover abundance values of less than 5% (Table 4). The densities of these seagrasses are also very sparse, with average values being 0.32, 0.31, and 0.14, respectively (Table 4).

Dredging will result in the loss of seagrass habitat due to removal, however, increases in depth or changes in bottom type that will result from the dredging may alter future growth patterns of seagrass in the area. The loss of these communities will result in the direct loss of habitat for marine animals. In particular, seagrass habitat is important in the juvenile life histories of many fishes and invertebrates. These juvenile species in turn, are a primary source of prey species for larger predatory fishes and invertebrates. There would be a net loss of primary and secondary production resulting from the loss of seagrass habitat.

4.1.2.1.2 Indirect Impacts

Indirect impacts to seagrass habitat from implementing Alternative S-1A or Alternative S-1B would include both temporary and long-term changes of habitats in the area associated with dredging. The areas just north of the widener cut and IEC and the seagrass habitats south of the DCC are subject to indirect impacts (Figures 8 and 9). Should dredging activities result in re-suspension of high concentrations of fine sediments into the water column, tides and currents may transport these sediments over adjacent seagrass beds where they may be deposited. Potential indirect losses of habitat or a temporary reduction in seagrass productivity and habitat quality may result. Other indirect impacts may include the temporary displacement of fish from these habitats adjacent to the dredging activities. This would result in short-term changes in the community structure within this area.

4.1.2.2 Impacts to Hardbottom and Reef

Widening and deepening associated with either Alternatives S-1A or S-1B would result in both direct and indirect impacts to hardbottom and reef communities within the Port Everglades OEC and IEC and adjacent habitats (Figure 11). These impacts would be both permanent and temporary.

4.1.2.2.1 Direct Impacts

Direct impacts to hardbottom and reef communities will occur as a result of the dredging process to widen and deepen the federal channel. As shown in Table 8 and Figures 15 and 16, there will be 14.60 acres of impact to reef habitat within the channel including 11.47 acres of low-relief reef and 3.13 acres of high-relief reef. New impacts outside the existing channel will include 2.15 acres of low-relief reef and 0.73 acre of high-relief reef. Approximately 27.57 acres of previously dredged hardbottom habitat (scattered rock/rubble 16.1 acres, low-relief reef 11.47) located in the OEC will be impacted by dredging. The impacts to these areas while direct would be temporary in nature, as marine life would re-colonize these areas following dredging. The area impacted consists primarily of a sponge-algal community consisting of the sponges *Ircinia* sp., *Niphates* sp., *Cliona* sp., and *Iotrochota* sp., and dominant algae associated with these communities are in the genus *Caulerpa* sp., *Jania* sp., *Laurencia* sp., *Dictyota* sp. and *Halimeda* sp. (Dodge 1991, Vare 1991). Interspersed among these sponges are colonial anemones (*Zoanthus* sp.), and hydrocorals (*Millepora alcicornis*).

Direct habitat loss to reef assemblages associated with dredging would be permanent. Loss of coral reef due to dredging would result in a change of the community structure offshore.

Impact to the reef habitat at the end of the OEC would result in direct removal of many coral species including a high density of gorgonians. These gorgonian corals are primarily of *Eunicea* sp., *Plexaura* sp. and *Pseudopterogorgia* sp. Hard coral species also make up a significant part of the reef assemblages in this area including *Porites asteroides*, *Diploria clivosa*, *Siderastrea siderea*, and *Montastrea cavernosa* (Britt 1977; Dodge 1991; Vare 1991). These coral species provide an important habitat for many other fish and invertebrate species.

4.1.2.2.2 Indirect Impacts

Indirect impacts to hardbottom and reef habitat associated with Alternatives S-1A or S-1B may include temporary changes to the habitats adjacent to the area being dredged. In particular, the reef and hardbottom habitats just outside of the entrance channel or within the local area offshore of the Port may be affected (Figures 15 and 16). Indirect impacts associated with the dredging activities of Alternatives S-1A or S-1B, may include the re-suspension and deposition of sediments within the adjacent area, the temporary displacement of fish and invertebrates from the area, and also acoustic effects of the associated dredging and blasting on marine life.

Dredging activities within the OEC may re-suspend fine sediments into the water column. This re-suspension of sediments may result in temporary periods of high turbidity within the area. The temporary effects of this high turbidity may include a loss of photosynthetic activity over the reef. Also, suspended sediments will be transported with the wind and tides and may be deposited on nearby coral reef communities. While corals can adjust and clean themselves with light deposition of sediments, if this deposition is too severe or long in duration it could result in the loss of the hard coral species. Monitoring of coral heads and collection of suspended sediments during past channel dredging of Port Everglades showed that little or no impact occurred (CSA 1981).

Other indirect effects include the displacement of fishes and invertebrates during the dredging activities. This would result from the loss of habitat in the area dredged and disturbance created by the dredging activities. The majority of these impacts would be short-term in nature and adjacent community assemblages would return to near normal levels after dredging activity ceased.

4.1.2.3 Impacts to Unvegetated Habitats

4.1.2.3.1 Direct Impacts

A large part of the area to be dredged includes areas of un-vegetated habitats. This habitat includes the softbottom habitats in the area as described by Messing and Dodge (1997) as well as others, and also the area of the SAC Channel (Figure 10) which is composed of softbottom habitat as well as scattered rubble from previous dredging activities. Both Alternative S-1A and

S-1B would include temporary impacts to benthic organisms utilizing these un-vegetated habitats within the Federal Channel and Port. Direct impacts to these softbottom communities would result from the removal of dredged material. In total there would be 214 acres of un-vegetated habitat altered during dredging during S-1A and 217.5 acres impacted with Alternative S-1B. As long as the areas remained as viable aquatic habitat following dredging, benthic populations in these areas would re-establish, and these losses would be temporary and short-term in nature.

4.1.2.4 Impacts to EFH

Alternatives S-1A and S-1B would impact designated EFH including estuarine emergent vegetation, mangrove shrub/scrub, live/hard bottom, coral reef, seagrass, and water column (Table 6). Managed species include the Snapper/Grouper complex, pink shrimp and spiny lobster. Both temporary and permanent impacts would occur.

Temporary impacts as a result of dredging the Entrance Channel would occur within the water column and to the softbottom and hardbottom benthic communities. Dredging and construction activities will temporarily impact benthic organisms that serve as food sources for EFH species. This foraging habitat would be temporarily unavailable. Since construction of other project elements will be phased over time and there is a large adjacent area left for foraging, these impacts should be minimal. Dredged habitats in the channel will be re-colonized by a similar benthic community within one year of dredging (Taylor et. al 1973).

Important aspects of EFH that may be affected by both Alternatives S-1A and S-1B include the loss of spawning, nursery, foraging and migration habitats. Particularly this would impact species of the Snapper/Grouper Complex, the spiny lobster and the pink shrimp. The most important losses to EFH within the area proposed for dredging include the loss of seagrass and coral reef. The coral reef habitats are listed as EFH-HAPC by the SAFMC. Loss of these two habitats will result in a loss of habitat critical in the spawning and early life stages for Snapper-Grouper Complex, which consists of 73 species that commonly use the inshore habitats for part of their life cycle. These include blue stripe grunts, French grunts), mahogany snapper, yellowtail snapper, and Red grouper. Seagrass areas impacted include approximately 2.09 acres of seagrass composed of *H. johnsonii*, *H. decipiens*, and *H. wrightii* with S-1A and 3.39 acres with S-2B. Reef impacts include the removal of 17.48 acres of reef habitat. Hardbottom habitats will re-colonize with benthic invertebrate species after dredging, however the loss of coral reef habitat will be permanent.

Blasting may be proposed as one of the methods for removal of rock during dredging. Blasting will have a direct impact on fish species within the Port area. Previous studies (USACE 1996; O' Keefe 1984; Keevin and Hempen 1997; Young 1991) have addressed the impacts of blasting on fishes. Fishes with air bladders are particularly more susceptible to the effects of blasting, while aquatic organisms without air bladders (e.g. shrimp, crabs, etc) are highly resistant to the impacts of blasting (Keevin and Hempen 1997). Small fish are the most likely to be impacted the greatest by blasting. Studies by the Corps of Engineers indicate that blasts in rock do not

have as great an impact as those detonated in open water (USACE 1999). In other projects requiring underwater explosives, buffer zones of 140 feet have proven to be effective in reducing the impacts to fish (Keevin and Hempen 1997).

Implementation of S-1A or S-1B would result in the permanent loss of 2.34 and 4.19 acres of estuarine mangrove, respectively; along John U. Lloyd SRA. This loss of mangrove habitat would result in a loss of EFH habitat for juvenile fishes. These mangrove areas serve a nursery for many managed species including pink shrimp, the spiny lobster, and members of the Snapper-Grouper Complex. Mangrove habitat is also important for many species of crabs, shrimp, and fishes not managed but serve as prey species for managed species. These include the blue crab, needlefishes (Belonidae), silversides (Atherinidae), killifishes (Cyprinodontidae) and livebearers (Poecillidae) (Odum 1982).

4.2 Alternatives S-5A, S-5B

Alternative S-5A and S-5B involve widening and deepening of the DCC to the north with a turning basin at the SAC. Alternative S-5A includes the construction of a bulkhead along the north side of the DCC and the creation of a bulkhead along the southern side of the DCC just north of West Lake Park (Figures 17 and 18). Alternative S-5B differs from S-5A in that the bulkhead along the southern side of the DCC would be replaced with a sideslope just north of West Lake Park (Figures 17 and 18). The impacts of these two alternatives are outlined in Table 8.

4.2.1 Impacts to Terrestrial Resources

Alternative S-5A would impact approximately 2.01 acres of mangrove wetlands along a 6 to 10 foot wide strip at the southern boundary of the DCC due to bulkhead construction, and for the turning basin construction at the juncture of the DCC and the AIWW. Alternative S-5B would impact approximately 3.28 acres of mangrove wetlands for the turning basin construction at the juncture of the DCC and the AIWW and associated sideslope. (Figures 17 and 18).

4.2.2 Impacts to Marine Resources

This section describes the potential direct and indirect impacts of construction activities as a result of Alternative S-5A or Alternative S-5B. The total impact acreages of these actions are summarized in Table 8. The direct impacts would involve the direct removal of habitat along the DCC, and SAC, while indirect effects are those effects that will affect nearby habitats and communities. All of these effects may be long-term or temporary in duration.

4.2.2.1 Impacts to Seagrass

Alternatives S-5A and S-5B have both direct and possibly indirect effects on seagrass along the southern edge of the DCC and also the SAC (Figures 17 and 18). These impacts will be both long-term and temporary and will impact *H. johnsonii*.

4.2.2.1.1 Direct Impacts

Dredging efforts to deepen and widen the DCC for implementation of Alternatives S-5A and S-5B will include the removal of approximately 0.66 and 0.69 acres of seagrass habitat, respectively. This habitat is a mixed bed of *H. decipiens*, *H. wrightii*, and *H. johnsonii*. This seagrass habitat occurs along the southern side of the DCC canal, near the SAC where a tidal creek merges with the DCC (Figures 17 and 18). This is the only seagrass encountered during the resource survey of the DCC. The seagrass here is very patchy and the bed overall is very poor, with average abundance values of 0.1000 and a density of 0.0031 (Table 4). *H. johnsonii* was so sparse that during sampling it was observed within the bed however, it was so scattered that it did not fall within any of the quadrats sampled along the study transect. The loss of this seagrass along the DCC will result in the loss of important seagrass habitat in this area, however; this habitat, overall, is not very high quality.

4.2.2.1.2 Indirect Impacts

Indirect impacts associated with Alternatives S-5A and S-5B would include both temporary and possible long-term impacts to the adjacent habitats. Dredging the DCC to accommodate larger vessels may re-suspend fine sediments into the water column. These sediments may increase turbidity and cut down on the photosynthetic activity of the adjacent seagrass areas within the SAC (Figures 17 and 18). Re-suspended sediments could also be transported and redeposited onto adjacent seagrass beds, resulting in long-term loss of habitat. Other indirect impacts include the displacement of fishes and invertebrates during dredging activities that would result in short-term changes in community structure.

4.2.2.2 Impacts to Unvegetated Habitats

4.2.2.2.1 Direct Impacts

The area impacted by Alternatives S-5A or S-5B includes approximately 24.6 acres of unvegetated habitat along the DCC and SAC (Table 8). This habitat consists primarily of areas that had been dredged in the past. This habitat is a mixture of unvegetated sediments and rubble

left from prior dredging events. The most consistent fauna within these communities consists of several taxa of polychaete, oligochaetes, mollusks, sipunculans, peracarid crustaceans, platyhelminthes, and nemertina (Messing and Dodge 1997, Rudolph 1986).

Direct impacts to these habitats will occur, but the impacts will be short-term in duration as community structure can be expected to re-establish itself following dredging.

4.2.2.3 Impacts to EFH

Impacts to EFH with the implementation of Alternatives S-5A or S-5B include impacts to mangrove scrub/shrub habitat, seagrass, and water column (Table 6). These impacts may impact managed species such as pink shrimp, spiny lobster, and members of the Snapper-Grouper Complex, as well as their prey species. These impacts would be both temporary and permanent.

Temporary impacts will occur along the DCC and SAC as a result of the dredging activities. The dredging will temporarily impact approximately 24.6 acres of unvegetated habitat and approximately 30 acres of water column. The dredging and construction of bulkheads will temporarily impact organisms using the DCC for migration and will also impact benthic prey species utilized by managed species within the area. The area of the DCC and SAC to be dredged will re-colonize following the completion of dredging activities and similar benthic communities can be expected to re-colonize the area.

The seagrass habitat impacted (0.66 or 0.69) along the DCC is an EFH-HAPC as listed by the SAFMC. Loss of this habitat may directly impact spawning, nursery, and foraging habitat for managed species within the Port. In particular, members of the Snapper-Grouper Complex, spiny lobster, and pink shrimp, may lose essential habitat important to their early life histories. Seagrass occurring in this area may serve as a nursery for the early development of these managed species, in addition to other species in the area of the Port.

4.3 Alternatives S-6A, S-6B

Alternatives S-6A and S-6B are another option for the deepening and widening of the DCC and SAC. S-6A would include the deepening and widening of the DCC with a turning basin at the SAC, construction of a bulkhead along the north side of DCC, and the creation of a bulkhead along the south side of the DCC into West Lake Park (Figures 19 and 20). Alternative S-6B includes the deepening and widening of the DCC and SAC, with construction of a bulkhead along the northern side of the DCC and a sideslope constructed into West Lake Park on the southern side (Figures 19 and 20).

4.3.2 Impacts to Terrestrial Resources

Alternative S-6A would impact approximately 18.82 acres of mangrove wetlands along a 160 to 230 foot wide strip at the southern boundary of the DCC and for the turning basin construction at the juncture of the DCC and the AIWW (Table 8) (Figure 19).

Alternative S-6B would impact approximately 25.56 acres of mangrove wetlands along a 250- to 320-foot wide strip at the southern boundary of the DCC and for the turning basin construction at the juncture of the DCC and the AIWW. Alternative S-6B differs from Alternative S-6A in that side slopes would be utilized to maintain channel integrity as opposed to bulkhead construction (Figure 19).

4.3.3 Impacts to Marine Resources

Impacts to marine resources in relation to Alternatives S-6A and S-6B will be evaluated in this section. Direct impacts are based on the number of acres of affected habitat, while indirect impacts are those impacts that may potentially affect nearby and adjacent habitats. These impacts may be long or short-term in duration.

4.3.3.1 *Impacts to Seagrass*

Implementation of either Alternatives S-6A or S-6B will result in both direct and indirect impacts to marine seagrass habitat (Figure 20). These impacts will be both temporary and permanent, and will directly affect the endangered *H. johnsonii*.

4.3.3.1.1 Direct Impacts and Indirect Impacts

Alternatives S-6A and S-6B would result in the removal of approximately 0.69 and 0.68 acres of marine seagrass habitat, respectively (Figures 19 and 20). These impacts are similar to those described in Section 4.2.2.1.

4.3.3.2 *Impacts to Unvegetated Habitats*

Impacts to unvegetated habitats with Alternatives S-6A or S-6B would include direct removal of either 22.73 or 23.77 acres of unvegetated marine habitat, respectively (Figures 19 and 20) (Table 8). These impacts would be similar to those described in Section 4.2.2.2, and this habitat should re-colonize following the completion of the dredging activities.

4.3.3.2.1 Direct Impacts

4.3.3.3 Impacts to EFH

Habitats that are designated as EFH that would be affected through either Alternative S-6A or Alternative S-6B include mangrove shrub/scrub, seagrass, unvegetated bottom, and water column (Table 6). These impacts would be both permanent and temporary and affect SAFMC managed species such as the spiny lobster, pink shrimp, and members of the Snapper-Grouper Complex, and related prey species.

Impacts to the unvegetated, water column, and seagrass habitats would be identical to the impacts described in Section 4.2.2.3 in relation to Alternatives S-5A or S-5B. However, the impacts to the mangrove habitats along West Lake Park are much greater with Alternatives S-6A and S-6B. Alternatives S-6A and S-6B impact 0.69 and 0.68 acres of seagrass, respectively. This mangrove habitat is high quality EFH and is listed as EFH-HAPC by the SAFMC. Mangrove habitat serves as nursery habitat for many of the managed and related species under the SAFMC plan (SAFMC 1998). This habitat is important in the life histories of managed species such as grunts, snappers, spiny lobsters, and their prey species (e.g., crabs, baitfish, and shrimp) (Odum et. al 1982). Removal of 18.82 or 25.56 acres of mangrove habitat along the DCC may have significant effects on the community structure and food chain within the study area through the loss of this habitat and its associated production.

4.4 Alternatives S-7, S-8

Alternative S-7 is the deepening of the NTB at Berths 2 and 3, while Alternative S-8 is the deepening of the STB to accommodate vessels at Berths 16, 17, and 18 (Figure 21). This deepening is to allow vessels with a larger draft to utilize the Port facilities.

4.4.1 Impacts to Marine Resources

Impacts to marine resources in relation to Alternatives S-7 and S-8 would include impacts to unvegetated bottom habitat and water column. These impacts would be both direct and indirect, and long and short-term in duration.

4.4.1.1 Impacts to Seagrass

4.4.1.1.1 Direct Impacts

There will no direct impacts to seagrass associated with Alternatives S-7 or S-8.

4.4.1.1.2 Indirect Impacts

Deepening of the NTN may have some indirect effects on the seagrass habitats within the Port. Dredging associated with deepening may re-suspend fine sediments into the water column. These sediments may increase turbidity and decrease photosynthetic activity. The NTN and IEC experience strong currents during tidal changes. These currents will redistribute these sediments to other areas within the Port and offshore and may deposit them on nearby seagrass habitats. This deposition of sediments may have adverse effects on these environments, including the loss of photosynthetic activity. Seagrass habitats adjacent to the area directly impacted by dredging may also experience temporary displacement of fish and invertebrate communities. The dredging activities will disrupt these communities near the northeastern corner of the TN and IEC. These communities should re-establish themselves once dredging is completed and any impacts would be short-term.

4.4.1.2 Impacts to Unvegetated Habitats

4.4.1.2.1 Direct Impacts

The largest area of impact with Alternative S-7 and S-8 are the unvegetated bottom habitats within the NTB and STB. This area consists of bottom habitats that have been dredged in the past, and are composed of unvegetated sediments and rubble. Alternative S-7 will impact 13.37 acres of unvegetated bottom, while Alternative S-8 will impact 19.74 acres (Table 8). As with the other unvegetated habitats discussed for the other alternatives, the impacts would be temporary and short-term, and the bottom within the NTB and STB would be expected to re-colonize shortly after dredging ceased.

4.4.1.3 Impacts to EFH

The proposed deepening of the NTB and STB associated with Alternatives S-7 and S-8 would impact designated EFH including unvegetated bottom and water column. (Tables 6 and 8) (Figure 21). These alternatives would potentially impact the migration, foraging, and reproductive activities of managed species within the area.

Temporary impacts to the water column and benthic communities would occur. Dredging activities would temporarily disrupt normal migration patterns within the area of the IEC, NTB, and STB. The dredging would also impact benthic communities in this area, which may provide habitat for prey species. This loss of foraging habitat would be temporary, and communities should recover within one year following dredging.

Most importantly this area may provide an important corridor for juvenile/adult fishes and invertebrates, migrating from inshore mangrove and seagrass communities to the reef habitats offshore. Dredging may temporarily impact these migration patterns in and out of the Port through the channel. These impacts may result in displacement of species during dredging and also hinder migration through the channel and AICWW. With the completion of dredging activities, these patterns should return to normal.

4.5 Alternatives S-9

Alternative S-9 involves extending the TN to the west and northeast to provide additional berthing and turning area (Figure 21). Impacts associated with Alternative S-9 include direct and indirect impacts to mangrove, unvegetated bottom, and the water column. These impacts will be both long and short-term in duration.

4.5.1 Impacts to Terrestrial Resources

Alternative S-9 would directly impact approximately 8.48 acres of mangrove wetlands (Table 8) (Figure 21). The mangrove wetlands that would be impacted by this alternative consist of a terminal rectangular area located west of the existing TN and are included in a designated wetland conservation area. The remaining 37 acres of mangrove wetlands in the conservation area would not be affected.

4.5.2 Impacts to Marine Resources

Alternative S-9 will directly and indirectly impact marine resources within the Port Everglades area. Marine resources impacted include unvegetated bottom and water column.

4.5.2.1 Impacts to Unvegetated Habitats

4.5.2.1.1 Direct Impacts

Alternative S-9 will directly impact 22.01 acres of unvegetated bottom. This area is primarily unvegetated sediments and rubble left from prior dredging events. This habitat is of very low quality and plays a minimal role in terms of primary and secondary estuarine productivity within the Port. Any impacts to this softbottom community will be short-term in duration. It is expected that the soft bottom biotic community will recover from the disturbance within one-year following dredging.

4.5.2.2 Impacts to EFH

Expansion of the TN with Alternative S-9 would impact EFH. In particular, it would impact mangrove shrub/scrub habitat, unvegetated bottom, and the water column. Impacts would be both direct and indirect and may impact managed species. The loss of 8.48 acres of mangrove habitat with expansion to the west would be the most significant impact (Figure 21) (Table 8). As described in earlier sections, this mangrove habitat is primary nursery habitat for marine fishes and invertebrates and removal would have significant effects on the community structure and food chain support within the area of the Port through the loss of this habitat and its related functional values. .

4.6 Impacts to Threatened and Endangered Species

This section assesses the potential impact to federally listed species that would result from the construction and/or operation of the Proposed Study Elements. Direct impacts to these species would include injury, mortality, or disturbance of individuals that directly affect the life history of these animals. Direct impacts would include those that may arise as a result of dredging, filling, and loss or modification of habitats. Indirect impacts would include impacts occurring to nearby habitats or animals within nearby areas either during or after completion of dredging and construction activities.

4.6.1 Impacts to Threatened and Endangered Species - All Alternatives

Federally listed species that may be potentially affected within the study area are shown in Table 9. These include the manatee, five species of sea turtle, and the seagrass *H. johnsonii*. Dredging activities associated with construction would present potential for direct mortality or injury to both manatees and sea turtles that may be moving through the area. The potential is greatest for Alternatives S-1A or S-1B, S-7, S8, and S-9. These potential impacts could be lessened with the

Table 9 Impact Analysis of Study Elements

	Seagrass		Hardbottom		Coral Reef		Mangrove		Sea Turtles		Manatees		H. johnsonii	
	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect
Study Element 1														
S-1A	3	1	1	2	3	2	1	1	1	1	2	1	3	1
S-1B	3	1	1	2	3	2	2	1	1	1	2	1	3	1
Study Element 5														
S-5A	2	0-1	0	0	0	0	2	1	0	0	1	1	3	0-1
S-5B	2	0-1	0	0	0	0	1	1	0	0	1	1	3	0-1
Study Element 6														
S-6A	2	0-1	0	0	0	0	3	1	0	0	1	1	3	0-1
S-6B	2	0-1	0	0	0	0	3	1	0	0	1	1	3	0-1
Study Element 7	0	0-1	0	0	0	0	0	0	0	0	2	1	0	0-1
Study Element 8	0	0-1	0	0	0	0	0	0	0	0	2	1	0	0-1
Study Element 9	0	0-1	0	0	0	0	2	1	0	0	2	1	0	0-1
No Action	0	0	0	0	0	0	0	0	0	0	0	0	0	0

0 – No impact

1 – Minor Impact

2 – Moderate Impact

3 – Significant Impact

use of seasonal restrictions on the amount of dredging allowed in peak seasons (i.e. manatees in winter, turtles' summer nesting season), and by using experienced observers during periods of dredging activity.

The highest potential impact to threatened and endangered species may be the use of explosives to remove areas of rock within the OEC, IEC, and SAC. Both the pressure and noise associated with blasting can physically damage marine mammals and turtles. Noise and pressure effects to manatees have not been well documented; therefore, this discussion will assume that manatees will be impacted similar to dolphins. The threshold of sea turtles to impacts is probably similar to dolphins (Department of the Navy 1998). Previous studies have determined that a blasting zone of 3,500 feet would be sufficient to minimize impacts to turtles and marine mammals (USACE 2000). This blasting zone should be monitored by experienced observers to assure no animals are within this zone prior to blasting. Adjustments can be made to the size of this blasting zone, depending on the type and size of the charges used and the actual noise and pressure measurements recorded during blasting. Further analysis will be required once a blasting plan has been prepared.

Other direct impacts may include the loss of habitat or minor impacts on secondary production. If all Study Elements are constructed a maximum of 4.6 acres of seagrass habitat could be lost. This habitat is potential foraging habitat for manatees that travel through this area. During winter months a large population of manatees use the warm water refuge at the FP&L Power Plant at Port Everglades. Given the large numbers of manatees in the area and the limited amount of seagrass present, any loss of seagrass may represent a loss of foraging habitat for manatees.

Dredging and construction activities in the area may also alter migration routes of manatees through the area. Care should be taken in winter months to assure that migration routes of manatees utilizing the FP&L warm refuge remain open and that dredging activities do not disturb the animals using this area. Any disturbance of manatees would be considered harassment of a marine mammal under the Marine Mammal Protection Act of 1972.

Removal of hardbottom and coral reef habitats for deepening of the Entrance Channel may eliminate some potential foraging habitat of marine turtles. However, due to the large area of similar habitat in the area, and the fact that these habitat areas will re-colonize over time, the impacts to turtle foraging habitat will most likely be temporary.

Direct impacts to sea turtles may occur if dredge material is used as renourishment material for the beach along John U. Lloyd SRA. As many as 212 sea turtle nests are found annually along this stretch of beach and any modifications to the beach could have an impact on nesting activity. Placement of dredge material during non-nesting periods and assuring the proper material grain size during placement will make any impacts associated with this insignificant. Dredging operations would require turtle observers be placed on board the dredge during active dredging to insure no incidental take to juvenile sea turtles occur.

Dredging will result in the removal of up to 2.25 acres of seagrass habitat where *H. johnsonii* occurs along the AICWW and DCC. This impact will include the direct removal of *H. johnsonii*. Changes in bottom depth through deepening and widening efforts within the Port, may limit the amount of available habitat suitable for *H. johnsonii* re-colonization. Since *H. johnsonii* does occur outside of the area directly impacted, it is reasonable to assume it would re-colonize within the Port area after construction halted assuming viable shallow water habitat still remained. Care should be taken during dredging efforts to limit the amount of fine sediment re-suspended to assure that impacts to adjacent seagrass beds would be minimized. A Biological Assessment should be prepared for these species and formal consultation with USFWS will be required pursuant to Section 7 requirements.

5.0 DREDGED MATERIAL DISPOSAL OPTIONS

The following dredged material disposal options are presently being considered as part of the overall study. Since it is presently unknown as to the preferred option(s) and/or combination of options to be selected, a detailed impact analysis without information such as volume of material, hauling/pumping methods, pumping distance, and pipeline corridor location cannot be completed. General assessments of probable impacts on marine resources are provided below.

5.1 Offshore Dredged Material Disposal Site (ODMDS)

A new ODMDS is presently being designated by EPA and the Corps of Engineers for disposal use (Figure 22). Since a draft EIS is being prepared by the Corps of Engineers, impacts for use of this site will not be addressed in this document. It is anticipated that the site will be approved for use in 2002 and can be considered a viable site for disposal of material unsuitable for other uses.

5.2 Beach Placement

It is anticipated that approximately six million cubic yards of dredged material could be placed on the beach at John U. Lloyd State Park. However, due to the amount of limestone rock it is anticipated that the material would have to be processed on land prior to placement on the beach. Assuming that the material could be processed to create beach quality sand suitable for sea turtle nesting and that the material would be placed above the MLW line, there would be only temporary impacts to the benthic community associated with the sandy beach and the epibenthic invertebrates and fish associated with the nearshore hardbottom habitat. Due to the small amount of material expected to be available for beach placement, and minimal extension of the tow of fill, no permanent impacts to marine resources are anticipated. With typical seasonal restrictions on beach fill and good Best Management Practices (BMPs) to minimize turbidity and sediment transport offshore, no long-term impacts are expected.

5.3 Airport Stockpile

The Airport is studying the option to allow the port to permanently temporarily store and use dredged material at the east end of the runway. No wetlands or protected species occur in this area. As long as the material is contained in a diked disposal area and BMP's are adhered to prevent erosion and runoff following storm events and dewatering, use of this site is not expected to have temporary or long-term adverse impacts.

5.4 Beneficial Uses for Habitat Creation and Restoration

Dredged material has long been considered and used to create and restore natural ecosystems. If material were suitable for habitat creation in West Lake Park and the county's master plan for the park would support use of the material a small amount could be used to create shallow water habitat suitable for mud flats, and seagrass natural recruitment and or planting. Negative impacts associated with the use of the material on existing marine resources within West Lake open water areas associated with use of the material would be minor as long as pipelines are carefully placed to minimize impacts to existing mangrove habitat and appropriate turbidity controls are adhered to when placing the material in the deeper areas of the estuarine embayment.

6.0 COMPENSATORY MITIGATION OPTIONS

This section outlines available options for providing compensatory mitigation for unavoidable impacts to mangrove, seagrass, unvegetated bottom, and offshore hardground/reef habitats potentially impacted by implementation of study elements considered in this document. Since the preferred suite of study elements to be combined have yet to be decided upon, only ranges of impacts are available for defining mitigation requirements and needs (Table 8). If one assumes combining one alternative from each element, the range in impacts (low to high) would include 3.44 to 4.77 acres of seagrass habitat, 32.48 to 41.39 acres of mangrove habitat, 17.48 acres of reef habitat, and 16.1 acres of deeper unvegetated rubble and sand/silt bottom located in the channel. Of these impacts, mitigation would be required for seagrass, mangrove, and reef /hardbottom habitats where new construction or dredging is proposed. All of these habitat types are considered EFH by the SAFMC and NMFS (SAFMC 1998). For dredging the rubble and silt/sand bottom within the channel, mitigation would not be required since dredging was previously performed in the channel and mitigation should not be required.

In addition to the impacts identified above, up to two acres of the mangrove habitat were previously restored as mitigation for past impacts. Mitigation required for this area would include compensation for taking the created mangrove area and for impacting it a second time for the proposed project. In the event land is taken on State owned park land, compensation will also be required above and beyond what is required for mitigation of wetland impacts. Once a decision is made relative to the recommended plan, these combined impacts can be further quantified.

6.1 Mitigation Policies

A summary of mitigation programs and policies in effect by federal reviewing agencies, including the EPA, USFWS, and NMFS, are provided below.

U.S. Environmental Protection Agency Mitigation Policy

Policy regarding mitigation under the Clean Water Act (CWA) Section 404(b)(1) guidelines were expressed within a Memorandum of Agreement (MOA) between EPA and the USACE and became effective February 7, 1990. The purpose of the MOA is to provide guidance to determine appropriate and practicable mitigation under the Section 404 Regulatory Program. Practicable is defined as “available and capable of being done after taking into consideration cost, existing technology, and logistics in light of the overall project purposes.”

According to the MOA, on-site mitigation is preferable to off-site mitigation. Similarly, in-kind mitigation is preferable to out-of-kind mitigation. However, EPA may accept off-site or out-of-kind mitigation if it is the most practicable solution. EPA expressed a preference of

restoration of wetlands over creation of wetlands from upland habitat for two reasons. First, EPA considers the likelihood of success higher for restored wetlands than for created wetlands. Second, EPA is concerned about the reduction of potentially valuable uplands resulting from the mitigation.

The MOA states that the objective of mitigation for unavoidable impacts is to offset environmental losses. Mitigation should provide, at a minimum, one for one functional replacement (i.e., no net loss of wetland value), with an adequate margin of safety to reflect the expected degree of success, but this requirement may not be appropriate and practicable in all cases. A minimum of 1:1 acreage replacement may be used as a reasonable surrogate for no net loss of functions and values where definitive information is lacking. However, this ratio may be greater where the wetland being impacted is high and the replacement wetlands are of lower functional value or the likelihood of success is low. Conversely, the ratio may be less than 1:1 for areas where the wetland being impacted is low and the likelihood of success associated with the mitigation proposal is high.

U.S. Fish and Wildlife Service Mitigation Policy

The U.S. Fish and Wildlife Service Mitigation Policy (January 23, 1981) established policy for USFWS recommendations on mitigating the adverse impacts of land and water developments on fish, wildlife, and their habitats. According to the policy, compensation may be accepted for wetland impacts in a variety of ways. Mitigation activities may include: wildlife management activities, habitat construction activities, fishery propagation, protective designations on public lands, buffer zones, property leases, wildlife easements, water right acquisition, and fee title acquisition. Compensatory mitigation actions should only occur after all efforts to avoid and minimize impacts have been utilized. USFWS policy states that appropriate mitigation for unavoidable wetland impacts are based on the resource value of the potential impacted wetland. Four categories of resource value have been defined by the USFWS for which different levels of mitigation may be determined.

A wetland classified as resource category 1 consists of high value wetland that is unique and irreplaceable on a national basis or in the eco-region. For this category, no loss of existing habitat value is the goal, and the USFWS will recommend that all losses of existing habitat be prevented.

A resource category 2 wetland is of high value and relatively scarce on a national basis or within the eco-region. For this category, the USFWS maintains a goal of no net loss of in-kind value. If unavoidable loss is likely to occur, in-kind replacement will be the recommendation. An exception to this rule may occur where the out-of-kind replacement is of greater value than the habitat to be impacted, or in-kind replacement is not physically or biologically obtainable in the region.

A resource category 3 wetland is of high to medium value and is relatively abundant on a national basis. The USFWS mitigation goal is no net loss of habitat value while minimizing loss of in-kind habitat value. For impacts to resource category 3 wetlands, in-kind

replacement is preferred. If in-kind replacement is not practicable, out-of-kind creation or restoration, or increased management of replacement habitat that increases the value of the existing habitat can achieve mitigation goals.

A resource category 4 wetland is of medium to low value, with a goal of minimum loss of habitat value. Compensatory mitigation for unavoidable losses to resource category 4 wetlands may be required,

National Marine Fisheries Service

As described in the Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), the EFH provisions of the act support one of the nation's overall marine resource management goals – maintaining sustainable fisheries.

The focus of the mitigation policy is to conserve and enhance EFH and to avoid, minimize, or compensate for impacts to EFH due to development activities. As with the other federal agency policies, the primary goal of any action is to avoid impacts to natural resources. However, if impacts to these resources are unavoidable, compensatory mitigation may be required. When unavoidable impacts to EFH occur, the NMFS will recommend mitigation measures to compensate for any loss of resource value. Recommendations may include: restoration of riparian and shallow coastal areas (i.e., re-establishment of vegetation, restoration of hardbottom characteristics, removal of unsuitable material, and replacement of suitable substrate), upland habitat restoration, water quality improvement or protection, watershed planning, and habitat creation. The preferred type of mitigation is enhancement of existing habitat, followed by restoration, and finally creation of new habitat.

Mitigation should focus on the replacement of lost habitat and associated values attributed to the habitat and toward maintaining sustainable fisheries. In particular, mitigation should be targeted toward impacts as a result of the proposed action (see Section 4.0) to the listed managed species discussed in Section 3.2.4.

Mitigation for EFH should focus on the replacement of lost habitat and associated values attributed to the habitat and towards maintaining sustainable fisheries. Since no definitive policy on mitigation is currently available on mitigating EFH impacts, development of mitigation strategies is subjective and somewhat difficult to address. Therefore, mitigation for EFH impacts must focus on strategies that enhance fisheries production and help ensure the sustainability of fisheries. Creation of mangrove habitat and mud flats, enhancement of fisheries resources by creating shallow water habitat or artificial structures, restoration of SAV habitat where feasible, and preservation of environmentally sensitive waterfront land threatened by development are all viable options that can compensate for impacts to EFH, and have been used and accepted elsewhere.

Mitigation requirements for EFH impacts, associated with proposed dredging of existing channels and basins, are difficult to define. While these areas will see a temporary loss of

benthic production, all the affected areas will see recruitment of the benthic community, followed by fish utilization of the habitat. All of these dredged areas will continue to provide food chain support and act as functional EFH habitat, including the turning basins, terminals and inner and outer entrance channels. Since the existing harbor basin provides seasonal fishery habitat, we would expect the proposed basin to likewise provide comparable habitat.

6.2 Mitigation Options

Compensation options for unavoidable impacts to coastal and marine habitats associated with implementation of the study elements are limited to those within the tidal influence of the Port Everglades entrance channel, including the West Lake property and land west of the Port property up the DCC. Other options would be considered off-site and as such may not be allowed by Broward County or would require a higher mitigation ratio.

6.2.1 West Lake

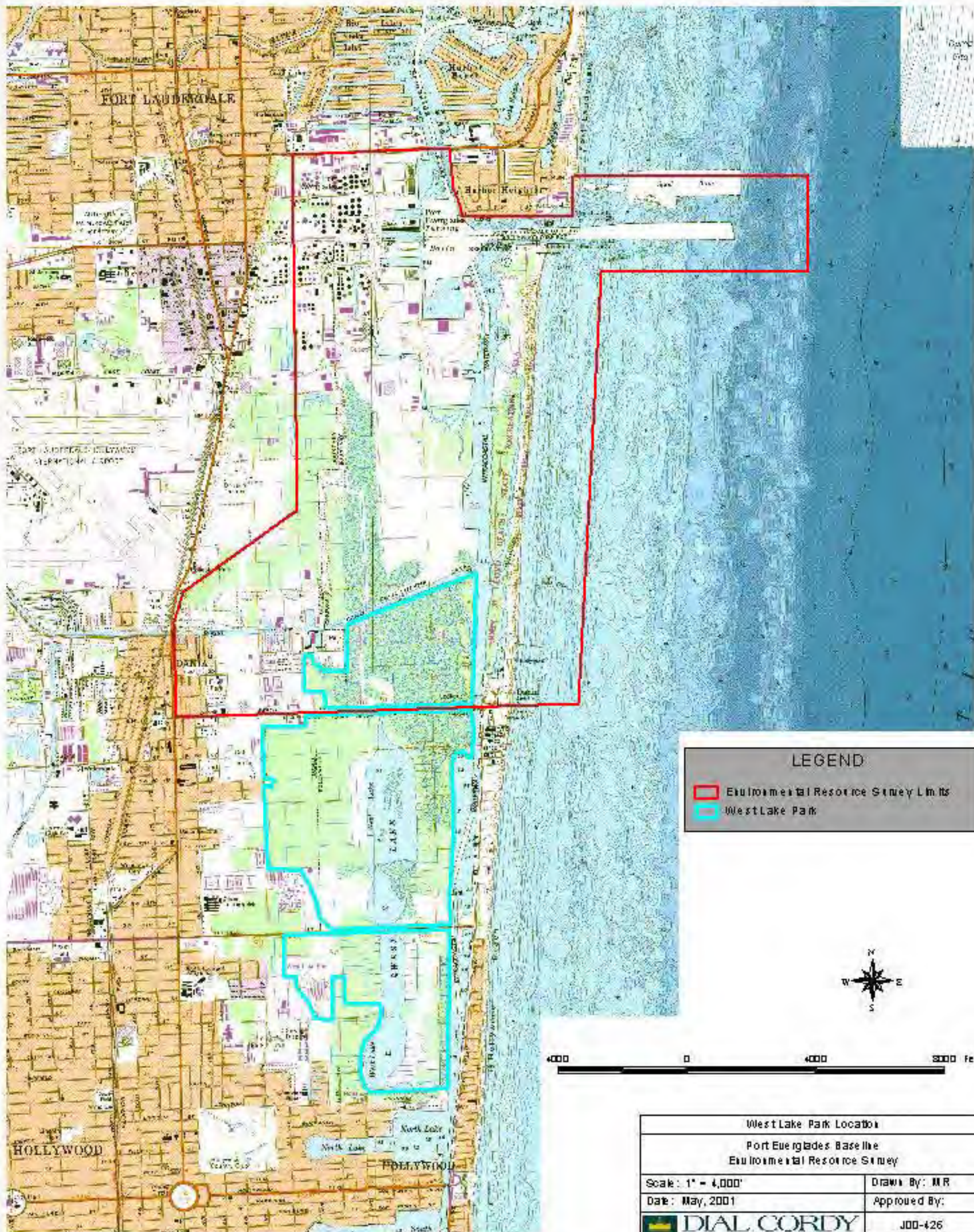
A West Lake Master Mitigation Plan is presently being developed by Broward County with the support of the Aviation, Parks and Recreation and Port Everglades Departments to restore and enhance wetlands and other ecosystems on the subject property (Figure 23). Mitigation options on the West Lake Park property will conform with the approved master plan under development and following agency concurrence. Following the approved agreement with the agencies on the proposed plan and credit values, the Port and airport will split the available values. It is anticipated that the plan will be approved by March 2002. A summary of conceptual creation, restoration, enhancement and acquisition opportunities are described below.

Mangrove Creation, Restoration and Enhancement Options

As conceptually proposed, the plan will include the creation, restoration and enhancement of mangrove wetlands through the eradication of exotic and nuisance vegetation, the re-grading/scraping down process and the planting of historically filled areas on 55 acres: in addition to creating other shallow water habitat such as mudflats. The plan may also include shoreline stabilization to provide more area for natural mangrove recruitment and creation of more tidal ditches to promote improved tidal flushing and water quality.

Shallow Water Habitat Restoration (seagrass and mudflats)

Opportunities to restore shallow water habitat suitable for the propagation of submerged aquatic vegetation are also being considered by Broward County, including planting seagrass in the shallow areas of West Lake and adjacent to the AIWW. One option recommended would be to use suitable dredged material from the DCC to fill deeper areas in West Lake, thus bringing the bottom elevation up to depths where light penetration is adequate to support SAV. Seagrass impacted from the AIWW channel could be transplanted within the filled



areas of West Lake prior to AIWW channel dredging. Based on review of aerial photographs of West Lake and discussions with Port Everglades staff (personal communication, Allan Sosnow, Port Everglades), it is possible that there are areas within the West Lake embayment that could be restored or enhanced through raising the bottom elevation and or planting submerged aquatic vegetation. Since bathymetric data is presently not available for West Lake Park the exact area available is unknown. Information required to assess the feasibility of restoration would include bathymetric mapping of West Lake open water areas, mapping of existing seagrass beds in West Lake, evaluation of existing sediment characteristics in potential areas of West Lake where restoration could occur and of available dredged material from DCC. In addition, photosynthetically active radiation (PAR) and salinity data for potential restoration areas in West Lake and from seagrass donor sites in the AIWW would be required. Following acquisition of this data a more thorough evaluation can be made and a detailed restoration plan prepared.

Land Acquisition and Preservation

To further enhance and protect ecological values in West Lake Park, a number of privately owned out-parcels are under consideration for acquisition as part of the overall master plan of West Lake Park. Protection of these parcels would provide more area for habitat restoration and enhancement in addition to providing a buffer from adjacent developed land. The acquisition of these parcels would help improve water quality throughout the park property. Assisting in acquisition of these parcels could serve to offset impacts associated with the taking of land from John U. Lloyd SRA.

6.2.2 Dania Cutoff Canal Property

Based on review of available aerial photography, there are other parcels of land located upstream of the port property in the DCC that are old agricultural lands adjacent to the DCC. These sites, if not contaminated or already planned for development, appear suitable for creating mangrove and shallow water habitat.

6.2.3 Florida Power & Light Everglades Mitigation Bank

This mitigation bank is operated by Florida Power & Light Company and readily sells credits for mitigation associated with mangrove impacts. This site is located in south Dade County and would be considered out of Broward County and off-site in terms of use, however, based on discussions with bank personnel (personal communication, Steve Collins, Everglades Mitigation Bank) Broward County is within the allowable service area for the mitigation bank. Presently, credits sell for \$45,000/credit for freshwater herbaceous credits and \$75,000/credit for mangrove and other saltwater credits. However due to the distance from the Port, it is probable that the credits required would be higher. Use of the bank would require concurrence from the state and federal resource agencies. A determination of the credits needed to supplement the overall required mitigation for mangrove impacts will require conducting a functional assessment of the mangroves to be impacted. It is recommended that

the bank be considered a supplemental source of mitigation credits in the event impacts cannot be fully mitigated for in the county.

6.2.4 John U. Lloyd SRA Mangrove and Shallow Water Habitat Replanting

In the event that study element 5b is included in the final plan, the shallow shelf excavated for widening could be replanted with mangroves. Mangroves could be removed from the area prior to dredging and stockpiled until construction is done, with some being used for replanting purposes. The remaining mangroves could be relocated and planted in restoration areas in West Lake Park. This would be considered on-site mitigation, as the West Lake property is adjacent to the Port.

6.2.5 Offshore Artificial Reef Placement

The implementation of either study element alternative S-1A or S-1B would impact 0.58 acres of reef community. This impact would result from the removal of this habitat with the associated widening and deepening of the OEC. To mitigate for this, artificial reef material can be placed in areas offshore to recreate reef habitat. Sites recommended for artificial reef creation by Broward County (personal communication, Ken Banks, Broward County DNRP) are shown in Figure 22. In addition to the creation of this habitat, a monitoring component can be added to the reef construction to assess the effectiveness of the reef material in creating habitat. Monitoring of artificial reefs and adjacent reefs will gauge the effectiveness of this option.

6.3 Effectiveness of Available Mitigation Options

A review of the effectiveness of each proposed mitigation treatment is summarized below.

6.3.1 Mangrove Restoration and Creation

Mangrove habitat has been successfully restored in the past. Restoration and rehabilitation have long been recommended for areas that have been altered or in areas where mangrove habitat cannot self-correct. Restoration of habitat is better in many cases than creating habitat. In areas where habitat is restored, natural recovery of mangrove habitat would offer the best mitigation options. The reestablishment of this habitat would occur if normal tidal hydrology is not interrupted and there are available stocks of adjacent mangroves. In the event that natural restoration could not occur creation of mangrove habitat would be another option. Planting of mangrove habitat would be adequate in areas where mangrove stocks would not normally reestablish. This option should only be exercised if natural recruitment would not occur.

6.3.2 Seagrass Restoration

Restoring seagrass beds, if successful, can be an appropriate mitigation strategy due to their high ecological value and declining abundance. Seagrass restoration adds habitat value to unvegetated sand or mud substrates. The addition of seagrass beds increases the productivity and diversity of the unvegetated bottom, which can directly compensate for the historic loss in productivity and diversity.

Fonseca et al. (1996a, 1996b) found that within two years, restored seagrass beds (*H. wrightii*) planted on 0.5-m centers reach the same areal density and support animal densities, number of taxa, and species composition equivalent to natural beds. Some restored seagrass beds support invertebrate populations that are as or more abundant than those in natural grassbeds (Bell et al. 1993). Restored seagrass beds appear to be as suitable as natural seagrass beds for juvenile and small adult fish (Brown-Peterson et al. 1993).

Restored seagrass beds support animal densities similar to natural seagrass beds when shoot density is only one-third that of a natural seagrass bed (Fonseca et al. 1996). Thus, the habitat value of a restored seagrass bed is maximized relatively quickly, prior to the restored bed reaching the same vegetative density as a natural seagrass bed. In addition to providing habitat itself, seagrass beds increase the productivity of adjacent habitats. Irandi and Crawford (1997) found that the presence of seagrass beds adjacent to tidal marshes increased the abundance and growth rates of fish in the tidal marsh.

Research has identified that seagrass beds are more diverse and productive than unvegetated substrate. Average fish densities in natural seagrass beds were ten times greater than those on unvegetated areas (~20 individuals/m² versus 1.74 individuals/m²). Shrimp densities in natural shoal grass beds averaged 151 individuals/m² compared to 3.02 individuals/m² in unvegetated areas. Crab densities in natural seagrass beds were 20 to 50 individuals/m² compared to an average of 1.91 individuals/m² on unvegetated areas (Fonseca et al. 1996). Within 1.5 years of planting, restored seagrass beds support shrimp, fish, and crab densities similar to natural seagrass beds (Fonseca et al. 1996). Thus, restored seagrass beds can increase the density of shrimp, fish, and crabs by 10 to 50 times compared to unvegetated substrates.

Although research has identified that seagrass beds are more diverse and productive than unvegetated substrates, relatively few studies compare secondary productivity between seagrass beds and other habitats. Heck et al. (1995) determined that eelgrass beds in the northeast had macroinvertebrate production 5 to 15 times higher than adjacent unvegetated habitats. At least a similar increase in productivity is expected for shoalgrass and turtlegrass, which have a higher primary productivity than eelgrass. Also, a similar increase in abundance, diversity, and productivity of fish species may also be expected.

Based on the scientific literature, a compensation ratio of two-acres of seagrass as compensation for one acre of impact is conceptually valid. This ratio acknowledges the increase in abundance, diversity, and productivity as a result of planting seagrass in existing unvegetated areas, as well as the increase in abundance and diversity of adjacent habitats. However, without guaranteed success and with the known high mortality of seagrass plantings (Fonseca et al. 1998), the resource agencies concern that this ratio is too low is valid. Should experimental seagrass restoration efforts prove that over 50% success can be achieved, then this ratio may be acceptable.

Restoration of seagrass communities, while still considered experimental and not highly successful by resource agencies, can enhance habitat heterogeneity and the diversity of invertebrate and fish communities, if carefully implemented. While seagrass restoration is an acceptable form of mitigation, none of the three commenting federal agencies are likely prepared to readily accept a form of mitigation that cannot be guaranteed. The recent treatise on seagrass restoration entitled "Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters" by Fonseca et al. (1998) discusses the benefits and risks associated with seagrass restoration. Given the documented success of more recent efforts to restore seagrass communities, restoration is quickly becoming a proven resource management tool in some areas where conditions are appropriate.

To achieve success in restoring seagrass communities, proper site selection, selection of planting techniques, care in installation of planting units, and incorporation of plant demography into the planning process must be strongly understood and adhered to by resource managers responsible for designing, funding, and construction. The lack of standard assessment techniques following planting has made evaluation of restoration success quite difficult (Race and Fonseca 1996). However, seagrass plantings that persist over multiple years and generate the target acreages have been shown to quickly provide functional attributes associated with natural seagrass beds.

6.3.3 Artificial Reef Construction

Currently there are many options for the construction of artificial reefs. Methods used previously have included limestone boulders, concrete tetrahedrons, and Reef BallsTM, among others. Broward County currently prefers the use of limestone boulders as the material for artificial reef construction (personal communication, February 5, 2001, Ken Banks Broward County Biological Resources Division). Currently there are three locations off shore of Broward County that may be utilized for artificial reef creation (Figure 22). These areas occur in water depths of 12 feet to over 400 feet MLW. Placement of limestone material in any or all of these areas would provide suitable habitat replacement for the loss of reef associated with widening and deepening.

6.3.4 Land Acquisition and Preservation

The purchase and preservation of ecologically valuable land adjacent to existing public lands or preserves is a viable and time accepted method of supplementing overall mitigation programs. While it is not the preferred method of compensation by most if not all resource agencies, it can provide considerable benefits to existing wetlands and as buffers for proposed restoration and enhancement areas. Benefits include providing vegetative buffers from developed areas, improving water quality in receiving waters, and providing access for recreational purposes. In many cases land acquisition includes purchasing land for restoration or enhancement purposes, whereby the purchased properties are placed in conservation.

7.0 REFERENCES

- Bell, S.S., L.A.J. Clements, and J. Kurdziel. 1993. Production in Natural and Restored Seagrasses: A Case Study of a Macrobenthic Polychaete. *Ecological Monographs* 3(4): 610-621.
- Braun-Blanquet, J. 1965. Plant sociology: the study of plant communities. Hafner Publications, London. 439p.
- Brown-Peterson, N.J., M.S. Peterson, D.A. Rydene, and R.W. Eames. 1993. Fish Assemblages in Natural versus Well-Established Recolonized Seagrass Meadows. *Estuaries* 16(2):177-189.
- Burney, C. and W. Margolis. 1999. Broward County Department of Natural Resource Protection Technical Report 00-01. Sea Turtle Conservation Program Broward County, Florida 1999 Report. 39pp.
- _____. 1998 Broward County Department of Natural Resource Protection Technical Report 99-01. Sea Turtle Conservation Program Broward County, Florida 1999 Report. 48pp.
- _____. 1997 Broward County Department of Natural Resource Protection Technical Report 97-08. Sea Turtle Conservation Program Broward County, Florida 1999 Report. 57pp.
- _____. 1996 Broward County Department of Natural Resource Protection Technical Report 97-01. Sea Turtle Conservation Program Broward County, Florida 1999 Report. 48pp.
- _____. 1995 Broward County Department of Natural Resource Protection Technical Report 95-05. Sea Turtle Conservation Program Broward County, Florida 1999 Report. 46pp.
- _____. 1994 Broward County Department of Natural Resource Protection Technical Report 94-09. Sea Turtle Conservation Program Broward County, Florida 1999 Report. 44pp.
- Continental Shelf Associates. 1981. Environmental Monitoring Associated with Port Everglades Harbor Deepening Project of 1980. Executive Summary. 15pp.
- Dial Cordy and Associates Inc. 1999. Marine Seagrass Survey of Port Everglades. Revised Final Report to U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL 26pp.

- Dodge, R.E., S. Hess, C. Messing, 1991. Final Report: Biological Monitoring of the John U. Lloyd Beach Renourishment: 1989. Prepared for Broward County Board of County Commissioners, Erosion Prevention District of the Office of Natural Resource Protection.
- Florida Land Use, Cover and Classification System. 1995. Department of Transportation State Topographic Bureau Thematic Mapping Section.
- Fonseca, M.S., D.L. Meyer, and M.O. Hall. 1996b. Development of planted seagrass beds in Tampa Bay, Florida, U.S.A: II. Faunal components. *Mar. Ecol. Prog. Ser.* 132:141-156.
- Fonseca, M.S., J.W. Kenworthy, and G.W. Thayer. 1998. Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters. NOAA Coastal Ocean Program Decision Analysis Series, No. 12. NOAA Coastal Ocean Office, Silver Spring, MD.
- Fonseca, M.S., W.J. Kenworthy, and F.X. Courtney. 1996a. Development of planted seagrass beds in Tampa Bay, Florida, U.S.A.:I. Plant components. *Mar. Ecol. Prog. Ser.* 132: 127-139.
- Heck, KL, K.W. Able, CT Roman, and MP Fahay. 1995. Composition, Abundance, Biomass, and Production of Macrofauna in a New England Estuary: Comparisons Among Eelgrass Meadows and other Nursery Habitats. *Estuaries* 18(2):379-389.
- Hoffmeister, J.E., K.W. Stockman, and H.G. Multer. 1967. Miami Limestone of Florida and its Recent Bahamian Counterpart. *Geological Society of America Bulletin.* 78:175-190.
- Irlandi, E.A., and M.K. Crawford. 1997. Habitat Linkages: the effects of intertidal saltmarshes and adjacent subtidal habitat on abundance, movement and growth of an estuarine fish. *Oecologia* 110:222-230.
- Jones, G.P., D.J. Ferrell, and P.F. Sale. 1991. Fish Predation and its Impacts on the Invertebrates of Coral Reefs and Adjacent Sediments. In *The Ecology of Fishes on Coral Reefs*. Academic Press Inc. 754pp.
- Keevin, T.M. and G.L. Hempen. 1997. The Environmental Effects of Underwater Explosions with Methods to Mitigate Impacts. U.S. Army Corps of Engineers, St. Louis District, St. Louis Missouri.
- Kenworthy, W.J. 1993. The distribution, abundance and ecology of *Halophila johnsonii* Eiseman in the lower Indian River, Florida. Final Report to the Office of Protected Resources, National Marine Fisheries Service, Silver Spring, MD. 72pp.

- Kenworthy, W.J. 1997. An updated status review and summary of the proceedings of a workshop to review the biological status of the seagrass *Halophila johnsonii* Eisemon. Report to Office of Protected Species, NMFS, NOAA. 23pp.
- Kenworthy, W.J., and M.S. Fonseca. 1996. Light requirements of seagrasses *Halodule wrightii* and *Syringodium filiforme* derived from the relationship between diffuse light attenuation and maximum depth distribution. *Estuaries* 19:740-750.
- Messing, C.G. and R.E. Dodge. 1997. Port Everglades Macroinvertebrate Monitoring. Monitoring of Benthic Macroinvertebrate Assemblages at the Southport Turning Basin and Adjacent Areas of John U. Lloyd State Recreation Area. Nova Southeastern University Oceanographic Center, Dania, FL. Prepared for Port Everglades Authority.
- O'Keefe, John David. 1994. Handbook on the Environmental Effects of Underwater Explosions. Research and Technology Department. Naval Surface Weapons Center NSWC TR 83-240. Silver Spring, Maryland.
- O'Shea, T.J., B.B. Ackerman, and H.F. Percival, Ed. 1995. Population Biology of the Florida Manatee. Information and Technology Report 1, U.S. Department of Interior, National Biological Service. 289 pp.
- Odum, W.E., C.C. McIvor, and T.J. Smith, III. 1982. The Ecology of the Mangroves of South Florida: A Community Profile. U. S. Fish and Wildlife Service, Office of Biological Sciences, Washington, D. C. FWS/OBS-81/24. 144 pp.
- Race, M.S., and M.S. Fonseca. 1996. Fixing compensatory mitigation: what will it take? *Ecological Applications*. 6:94-101.
- Rudolph, H. 1986. Broward County BAS Biological Study Results.
- Sale, P.F 1991 The Ecology of Fishes on Coral Reefs. Academic Press Inc. San Diego, California. 754 pp.
- Seaman, W., Jr. Ed. 1985. Florida Aquatic Habitat and Fishery Resources. Florida Chapter of American Fisheries Society. 542 pp.
- Spieler, R.E. 1998. Recruitment of Juvenile Reef Fish to Inshore and Offshore Artificial Reefs: Final Report. Broward County Department of Natural Resource Protection. Technical Report 98-02. 117 pp.
- South Atlantic Fishery Management Council 1998. Final Comprehensive Amendment Addressing Essential Fish Habitat in Fishery Management Plans of the South Atlantic Region. Charleston, SC. 142 pp.

- South Atlantic Fishery Management Council 1998. Final Habitat Plan for the South Atlantic Region: Essential Fish Habitat Requirements for Fishery Management Plans of the South Atlantic Fishery Management Council. Charleston, SC. 408 pp.
- Taylor, J.L., C.H. Salomon, and K.W. Priest, Jr. 1973. Harvest and Regrowth of Turtle Grass (*Thalassia testudinum*) in Tampa Bay, Florida. U.S. Natl. Mar. Fisheries Service Fisheries Bulletin. 71(1): 145-148.
- U.S. Army Corps of Engineers (USACE) 1996a. Coast of Florida Beach Erosion and Storm Effects Study, Region III, Feasibility Report with Final Environmental Impact Statement. Prepared by Gulf Engineers and Consultants, Inc.
- U.S. Army Corps of Engineers (USACE) 1996b. Final Feasibility Report and Environmental Impact Statement on Improvement of Navigation, Cape Fear-Northeast Cape Fear Rivers Comprehensive Study, Wilmington North Carolina, Volumes I,II, and III.
- U.S. Army Corps of Engineers (USACE) 1999. Final Mitigation Plan for Direct Project Impacts, Wilmington Harbor, North Carolina 96 Act. Revised January 1999.
- U.S. Army Corps of Engineers (USACE). 2000. Broward County, Florida Shore Protection Project General Reevaluation Report. Prepared by Coastal Planning and Engineering Inc./Olsen and Assoc. Inc.
- Vare, Carmen N. 1981. A Survey, Analysis, and Evaluation of the Nearshore Hardbottom Reefs Situated off Palm Beach County, Florida. Thesis submitted to the College of Social Science, Florida Atlantic University: Boca Raton, Florida.
- Virnstien, R.W. and L.J. Morris. 1996. Seagrass Preservation and Restoration: A Diagnostic Plan for the Indian River Lagoon. Tech. Mem. #14. St. Johns River Water Management District, Palatka, FL. 43pp.
- Zieman, J.C. 1982. The Ecology of Seagrasses of South Florida: A Community Profile. U.S. Fish and Wildlife Services, Office of Biological Services, Washington, D.C. FWS/OBS-82/25. 158pp.

APPENDICES

Appendix A

Sources of Information

Appendix A: List of Persons Consulted

Name	Affiliation	Information
Allan D. Sosnow	Port Everglades, Department of Broward County	Wetland map, general resource information, overall project plan
Charles G. Messing, Ph.D.	Nova Southeastern University	Benthic community data
Kurt J. Volker	Broward County Commission, Parks and Recreation Department	West Lake Park Management Plan
Gill MacAdam	Broward County Commission, Parks and Recreation Department	West Lake Park Management Plan
David Stout	Broward County Commission, Department of Planning and Environmental Planning	Turtle Monitoring Reports, Fish inventories
Pam Fletcher	Broward County Commission, Department of Planning and Environmental Planning	Manatee data
Lou Fisher	Broward County Commission, Department of Planning and Environmental Planning	Coral Reef data
Mike Johnson	National Marine Fisheries Service	Seagrass information
Chris Creed	Olsen and Associates	Reef Maps
Steve Dale	Florida Department of Environmental Protection, John U. Lloyd State Park	Park management plan
Ephrat Yovel	Florida Department of Environmental Protection, Park Planning	John U. Lloyd Draft Management Plan
Delores Smith	Fort Lauderdale/Hollywood International Airport	Information on Airport Expansion and maps of property
Steve Higgins	Broward County Commission Department of Planning and Environmental Protection (DPEP) Biological Resources Division	Coral Reef Mapping and County Resource Reports
Ken Banks	Broward County Commission DPEP	Artificial Reefs
Mike Knoll	Miller Legg	Final Mitigation Plan for Port
Mark Thompson	National Marine Fisheries Service	Seagrass information, information on blasting effects to wildlife
Richard Dodge, PhD.	NOVA University	Benthic Mapping and Monitoring
David Burnhart	NMFS	Effects of Blasting References
Carol Knox	Florida Fish and Wildlife Conservation Commission	Manatee Data
John Meshaw	Wilmington District USACE	Blasting Effects Study
Frank Yelverton	Wilmington District USACE	Blasting Effects Study
Bill Adams	Wilmington District USACE	Blasting Effects Study
Steve Collins	Everglades Mitigation Bank	Mitigation Options

Appendix B

Florida Natural Area Inventory Listed Species Broward County

Florida Natural Area Inventory Listed Species, Broward County

Available at the Jacksonville District U.S. Army Corps of Engineers Office

Appendix C

Survey Photographs



Photo 1: Parrotfish and wrasse in sea whip along reef transect.



Photo 2: Representative hard coral along transect.



Photo 3: Colony of Christmas tree worms along reef transect.



Photo 4: Coral and sponges representative of transect along nearshore reef area.



Photo 1: Octocoral and sergeant majors along reef transect nearshore.



Photo 2: Representative staghorn coral and gorgonians along nearshore transect.

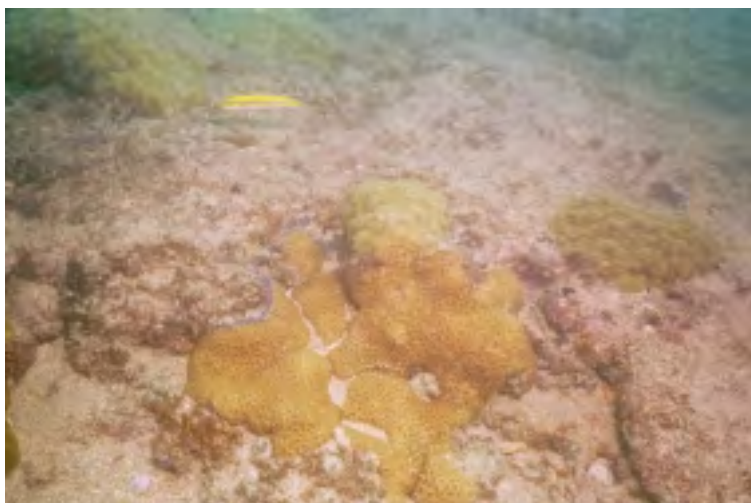


Photo 3: Stony corals representative of nearshore transect.



Photo 4: Seafan and stony corals along nearshore transects.

Appendix D

Seagrass Field Data Sheets (2000 Survey)

Transect	Total Quadrat	Occupied Quadrats	Sub Units	Occupied Sub Units	Sum Cover Score	Species	Frequency	Abundance	Density
PE1	4	2	64	6	0.6	HD	0.0938	0.3000	0.1500
PE2	4	2	64	22	2.5	HD	0.3438	1.2500	0.6250
PE3	4	1	64	1	0.1	HD	0.0156	0.1000	0.0250
PE6	6	2	96	6	0.6	HD	0.0625	0.3000	0.1000
PE8	4	1	64	5	0.5	HD	0.0781	0.5000	0.1250
PE10	7	1	112	4	0.1	HD	0.0357	0.1000	0.0143
PE12	6	3	96	3	0.3	HD	0.0313	0.1000	0.0500
PE14	8	1	128	8	0.5	HD	0.0625	0.5000	0.0625
PE1A	4	4	64	31	5	HD	0.4844	1.2500	1.2500
PE2A	7	5	112	75	17	HD	0.6696	3.4000	2.4286
PE3A	4	1	64	11	2	HD	0.1719	2.0000	0.5000
PE4A	2	1	32	16	5	HD	0.5000	5.0000	2.5000
PE5A	4	2	64	13	1.1	HD	0.2031	0.5500	0.2750
PE6A	4	2	64	25	5	HD	0.3906	2.5000	1.2500
PE7A	3	1	48	10	1	HD	0.2083	1.0000	0.3333
PE8A	4	2	64	2	0.2	HD	0.0313	0.1000	0.0500
PE9A	7	5	112	47	6.1	HD	0.4196	1.2200	0.8714
PE6	6	2	96	11	2.1	HJ	0.1146	1.0500	0.3500
PE7	5	2	80	14	1.1	HJ	0.1750	0.5500	0.2200
PE8	4	1	64	3	0.1	HJ	0.0469	0.1000	0.0250
PE12	6	3	96	14	2.6	HJ	0.1458	0.8667	0.4333
PE13	5	1	80	14	2	HJ	0.1750	2.0000	0.4000
PE14	8	2	128	4	0.2	HJ	0.0313	0.1000	0.0250
PE1A	4	1	64	16	4	HJ	0.2500	4.0000	1.0000
PE5A	4	1	64	16	3	HJ	0.2500	3.0000	0.7500
PE9A	7	2	112	13	4	HJ	0.1161	2.0000	0.5714
PE2A	7	3	112	27	2.5	HW	0.2411	0.8333	0.3571
PE13	5	2	80	18	2	HW	0.2250	1.0000	0.4000
PE14	8	1	128	2	0.1	HW	0.0156	0.1000	0.0125
PE5A	4	2	64	30	3	HW	0.4688	1.5000	0.7500
PE8A	4	1	64	2	0.1	HW	0.0313	0.1000	0.0250
PE9A	7	3	112	16	4.1	HW	0.1429	1.3667	0.5857
PE4									
PE5									
PE9									
PE11									

HD Overall Frequency
 0.2237

 HD Overall Abundance
 1.1865

 Overall Density
 0.6241

HJ Overall Frequency
 0.1450

 HJ Overall Abundance
 1.5185

 Overall Density
 0.4194

HW Overall Frequency
 0.1874

 HW Overall Abundance
 0.8167

 Overall Density
 0.3551

Appendix E

Bird Species List Broward County

Bird Species List, Broward County

Available at the Jacksonville District U.S. Army Corps of Engineers Office

Appendix D

D-2

Benthic Assessment

Benthic and Fish Community Assessment At Port Everglades Harbor Entrance Channel

FINAL DRAFT

**Prepared for
Jacksonville District
U.S. Army Corps of Engineers
701 San Marco Blvd.
Jacksonville, FL 32207**



**by
Dial Cordy and Associates Inc.
490 Osceola Avenue
Jacksonville Beach, FL 32250**

December 2009

EXECUTIVE SUMMARY

The Jacksonville District U.S. Corps of Engineers (USACE) is conducting a feasibility study in part to evaluate the widening and deepening of the Outer Entrance Channel (OEC) of Port Everglades Harbor (Broward County, Florida). The proposed improvements would impact offshore marine biological resources, including reef communities offshore of the port. Dial Cordy and Associates Inc. (DC&A) was contracted by the USACE to map existing benthic habitats and quantitatively assess population levels of reef biota, particularly sessile organisms (i.e., macroalgae, sponges, octocorals, and hard corals) and reef fish associated with the two north-south oriented, parallel reef tracts that are likely to be directly or indirectly impacted by OEC improvements. The habitat equivalency assessment and mitigation required for these proposed impacts will be addressed in the Habitat Equivalency Assessment (HEA) Report and the Mitigation Plan.

Investigations involved study sites located on the outermost two of three, shore-parallel fossil reefs that support modern sponge, octocoral and coral communities in water depths ranging from approximately 8 to 21 meters (m). These fossil reefs were elkhorn coral communities which were drowned by sea level rise 5000 to 7000 years ago. The outermost reef is here referred to as the "outer reef," or "third reef. The "middle reef" is also referred to as the "second reef." Neither the innermost shore-parallel fossil reef (inner reef) nor the shoreward hardbottom zone was investigated for this study since the scope of work did not include these areas

During February and March 2006, a total of 41 sampling stations were assessed on the second and third reefs. Sampling sites included areas both within and adjacent to the footprint of the proposed OEC improvements on the second reef (Reef 2 (R2)) and third reef (Reef 3 (R3), R3-PI, and R3-C). Benthic organisms were assessed along belt transects using *in situ* visual assessments of benthic organisms, underwater videography, and *in situ* visual observations of reef fish. Individual belt transects were 10 m long and 1 m wide for the *in situ* visual assessments, and 10 m long and 40 centimeters (cm) wide for video transects. The dimensions of the belt transects were based on methods applied to coral habitats in Florida and the Caribbean province (e.g., Loya 1976; Rogers et al. 1983; Liddell et al. 1984; Aronson and Precht 1995). Parameters used to characterize the benthic organisms from visual surveys included scleractinian (hard coral) species diversity (H'), species richness, and colony density. *In situ* data collected for octocorals and sponges were taken to the lowest possible taxonomic level. Videographic surveys yielded information on the percent cover of scleractinians, octocorals, hydrocorals, macroalgae, turf algae, unconsolidated sediments, and rubble on the seafloor. Species richness was also evaluated from the videographic transects. Fish censuses included stationary counts and counts conducted along belt transects which provided estimates of fish species richness, abundance, and size.

Sites surveyed within and adjacent to OEC improvements were low in live cover of benthic organisms including corals, octocorals, and sponges, while bare space and turf algae were abundant. These results are similar to some comparative sites (e.g. BC2 and BC3 from Gilliam 2007). With respect to octocoral and sponge density and cover, the lower values found at R2, R3, R3-PI, and R3-C may be related to inlet water quality issues (Griffin and Lipp 2009; Reich et al. 2009) and mechanical damage due to anchoring and other impacts associated with a channel that serves commercial as well as recreational users.

Analyses of collected data showed many differences between the biota of the third and second reefs. Third reef sites (R3, R3-PI, and R3-C) were more developed biologically compared to R2. Third reef sites supported greater hard coral colony densities, coral cover, and octocoral colony densities. The analyses of the data collected for this study corroborated Gilliam et al.'s (2006) assessments of the differences between second and third reef benthic communities.

Reef 3 (R3) was located within the proposed OEC extension area. Site substrates at R3 consisted of hardbottom, rubble, rocks, pockets of coarse and fine sand, and few artificial substrates. Less than 3 percent (%) of the scleractinians observed at R3 had some form of bleaching or coral mortality; species most affected were *Siderastrea siderea*, (massive starlet coral), and *S. intersepta*, (blushing star coral).

Two species of coral, *Acropora palmata* (elkhorn coral) and *A. cervicornis* (staghorn coral), found off Broward County are listed as threatened species under the Endangered Species Act of 1973 (ESA), as amended (50 CFR Part 223). During field reconnaissance and quantitative surveys in February and March 2006, neither of these species were observed within study sites.

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	II
LIST OF TABLES	VI
LIST OF FIGURES	VIII
1.0 INTRODUCTION.....	1
1.1 Study Context and Objectives	1
1.2 Study Area.....	1
2.0 METHODS	4
2.1 Initial Benthic Habitat Mapping	4
2.2 Benthic Habitat Reconnaissance.....	4
2.3 Quantitative Benthic Community Assessment.....	4
2.3.1 Study Design	4
2.3.3 Sampling Design	11
2.3.3.1 Visual Assessment of Benthos.....	15
2.3.3.2 Videographic Assessment of Benthos.....	16
2.4 Fish Census	17
3.0 RESULTS.....	18
3.1 Benthic Survey – Visual Assessment.....	18
3.1.1 Sampling Site Characteristics	18
3.1.2 Sample Size Adequacy	20
3.1.3 Benthic Organisms	21
3.1.3.1 Hard Corals-Scleractinians.....	21
3.1.3.2 Hard Corals-Hydrocorals.....	28
3.1.3.3 Octocorals	32
3.1.3.4 Sponges	36
3.1.3.5 Zoanthids	36
3.1.3.6 Algae	39
3.2 Benthic Organisms – Videographic Assessment.....	40
3.2.1 Comparisons of Percent Cover of Functional Groups Within and Between Reefs ...	40
3.2.1.1 Scleractinians.....	43
3.2.1.2 Shannon-Weiner Diversity Index for Coral Species	44
3.2.1.3 Octocorals	45
3.2.1.4 Sponges	46
3.2.1.5 Macroalgae	47
3.2.1.6 Turf Algae.....	48
3.2.1.7 Sediment and Rubble.....	49
3.2.2 Pearson’s Correlation Coefficient Results	50
3.3 Reef Fish Assemblages	51

4.0	DISCUSSION	55
4.1	Second Reef Comparisons.....	56
4.1.1	Hard Corals	58
4.1.2	Octocorals	58
4.1.3	Sponges, Zoanthids, and Algae	59
4.1.4	Potential Impact Area	59
4.2	Third Reef Comparisons	59
4.2.1	Hard Corals	60
4.2.2	Octocorals	61
4.2.3	Sponges, Zoanthids, and Algae	62
4.3	Conclusion.....	63
5.0	LITERATURE CITED	64

Appendix A Visual Data

Appendix B Videographic Data

LIST OF TABLES

	Page
Table 1. Sampling hierarchy, Port Everglades benthic assessment, March 2006.....	5
Table 2. Sizes of study sites surveyed off Port Everglades, Florida.....	11
Table 3. DGPS locations of random sampling stations (points), random bearing of each belt transect (T), and the distance used to locate the origin of belt transects away from station markers.....	13
Table 4. Reef site-zone, sampling point, number of samples and corresponding sampled area of visual and videographic transects conducted off Port Everglades in March 2006 [R=Reef; Z=Zone; P=Previously Impacted; C = Control; N=North; S=South; RP=Random Point]	14
Table 5. General substrate characteristics by reef site and zone off Port Everglades based on visual belt transects conducted in March 2006. Presence of a substrate is indicated by an "x." [R =Reef; Z = Zone; PI = Previously Impacted; C = Control].....	20
Table 6. Number of scleractinian colonies, species richness, and density of scleractinian colonies by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. [SD = standard deviation; N = number of belt transects; R = Reef; Z = Zone; PI = Previously Impacted; C = Control].....	21
Table 7. Number of scleractinian colonies by species, reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Species are listed in alphabetic order. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	23
Table 8. Scleractinian species diversity (H') based on the abundance of coral colonies in visual belt transects off Port Everglades in March 2006. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control].....	24
Table 9. Significant differences in scleractinian species diversity (H') resulting from Hutcheson's modified t-test (Hutcheson 1970) as applied to coral colony counts in visual belt transects off Port Everglades in March 2006. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control].....	24
Table 10. Distribution of the scleractinian colony sizes (diameter) by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Sizes were organized in five size classes: Class I = 0-3 cm; Class II = 4-10 cm; Class III = 11-25 cm; Class IV = 26-50 cm; and Class V = > 50 cm. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control].....	26
Table 11. Distribution of the scleractinian colony sizes by species, reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Sizes were organized in four size classes: Class I = 0-3 cm; Class II = 4-10 cm; Class III = 11-25 cm; and Class IV = 26-50 cm. Species are listed in alphabetic order. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	29
Table 12. Individual incidences of afflicted/stressed corals by reef site, zone, and sampling station (RP).	30
Table 13. Distribution of <i>Millepora</i> colony sizes by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Sizes were organized in four size classes: Class I = 0-3 cm; Class II = 4-10 cm; Class III = 11-25 cm; and Class IV = 26-50 cm. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control].....	31

Table 14.	Distribution of <i>Millepora alcicornis</i> colony sizes by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Sizes were organized in four size classes: Class I = 0-3 cm; Class II = 4-10 cm; Class III = 11-25 cm; and Class IV = 26-50 cm. Species are listed in alphabetic order. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	31
Table 15.	Number of octocoral colonies by genus, reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Genera are listed in alphabetic order. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	32
Table 16.	Number of octocoral colonies and genera, and density of colonies by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. [SD = standard deviation; R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	33
Table 17.	Distribution of the octocoral colony sizes (height) by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Sizes were organized in five size classes: Class I = 0-10 cm; Class II = 11-25 cm; Class III = 26-50 cm; Class IV = > 50 cm. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	34
Table 18.	Occurrence of sponge genera off Port Everglades in March 2006 by reef site and zone. Presence is indicated by an "x." [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	37
Table 19.	Mean colony density of <i>Xestospongia muta</i> (barrel sponge) by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	37
Table 20.	Occurrence of algae (genus) by reef site and zone as recorded in visual belt transects off Port Everglades in March 2006. Presence is indicated by an "x." [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	40
Table 21.	Percent cover of functional group categories as recorded in video belt transects off Port Everglades in March 2006 [SE = standard error; Values do not add up to 100% because "other" and "unknown" categories of cover are not presented]	41
Table 22.	Scleractinian corals and the hydrocoral <i>Millepora alcicornis</i> percent-cover per reef site and zone as recorded in video belt transects off Port Everglades in March 2006.....	42
Table 23.	Shannon-Weiner diversity Index (H') calculated for corals for each reef site and zone as recorded in video belt transects off Port Everglades in March 2006.....	45
Table 24.	Pearson's Correlation Coefficient results for the sand, pavement, rubble (SPR) category against other functional group categories based on data acquired in video belt transects off Port Everglades in March 2006. [The closer the top value was to 1 or -1, the stronger the correlation. P-values are reported underneath the correlation coefficient]	50
Table 25.	List of fish species identified on each of the treatments March 2006	51
Table 26.	Comparison of coral cover (%), and coral, octocoral, and sponge density at sites closest to Port Everglades. Reef 2 (second reef) and Reef 3 (third reef impact area) data are from this study; JUL 7, JUL8, FTL 2, FTL 3 data are taken from Gilliam et al. (2006); and BC2 and BC3 data are taken from Gilliam (2007).....	56
Table 27.	List of scleractinian species found on the third reef as reported in Goldberg (1973) off Boca Raton, Gilliam et al. (2006) off Broward County, and this study	61
Table 28.	List of octocoral genera found on the third reef (Reef 3, R3-PI, R3-C) in this study and as reported in Goldberg (1973) off Boca Raton.....	62

LIST OF FIGURES

	Page
Figure 1. Location of Study Sites	3
Figure 2. Conceptual proposed reef impact area associated with Outer Entrance Channel improvements.....	6
Figure 3. Reef Study Zones	7
Figure 4. Random sampling points for transect locations, Reef 2	8
Figure 5. Random sampling points for transect locations, Reef 3 site.....	9
Figure 6. Random sampling points for transects, Reef 3 Control and Previously Impacted sites.....	10
Figure 7. Scleractinian coral species richness rarefaction curves based on visual transects acquired at Reef 2 and third reef sampling sites off Port Everglades, Florida in March 2006	22
Figure 8. Scleractinian species richness (S) by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	23
Figure 9. Scleractinian colony density (\pm SD) by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control].....	25
Figure 10. Distribution of scleractinian colony sizes (diameter) within reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Class 1 = 0-3 cm; Class 2 = 4-10 cm; Class 3 = 11-25 cm; Class 4 = 26-50 cm; and Class 5 = > 50 cm. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	26
Figure 11. Mean octocoral colony density (\pm SD) by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control].....	33
Figure 12. Distribution of octocoral colony sizes (height) within reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Class I = 0-10 cm; Class II = 11-25 cm; Class III = 26-50 cm; Class IV = > 50 cm. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	35
Figure 13. <i>Xestospongia muta</i> (barrel sponge) colony density (\pm SD) by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	38
Figure 14. Abundance of barrel sponges (<i>Xestospongia muta</i>) by size class (height) and by reef site and zone as recorded in visual belt transects off Port Everglades in March 2006. Class I = 0-25 cm; Class II = 16-50 cm; Class III = > 50 cm. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control].....	38
Figure 15. Abundance of the zoanthid <i>Palythoa caribaeorum</i> by size class (diameter) and by reef site and zone as recorded in visual belt transects off Port Everglades in March 2006. Class I = 0-25 cm; Class II = 16-50 cm; Class III = > 50 cm. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]	39
Figure 16. Mean percent cover data for nine functional groups at four reef sites as recorded in video belt transects off Port Everglades in March 2006.	40

Figure 17.	Percent cover for hard coral category at each reef site and zone (\pm SE) as recorded in video belt transects off Port Everglades in March 2006.	43
Figure 18.	Percent cover of five dominant coral species at each reef site and zone (\pm SE) as recorded in video belt transects off Port Everglades in March 2006.	44
Figure 19.	Mean percent sponge and octocoral cover by reef (\pm SE) as recorded in video belt transects off Port Everglades in March 2006.	45
Figure 20.	Mean percent octocoral cover by reef site and zone (\pm SE) as recorded in video belt transects off Port Everglades in March 2006.	46
Figure 21.	Mean percent sponge cover by reef site and zone (\pm SE) as recorded in video belt transects off Port Everglades in March 2006.	47
Figure 22.	Mean percent macroalgae cover by reef site and zone (\pm SE) as recorded in video belt transects off Port Everglades in March 2006.	48
Figure 23.	Mean percent turf algae cover by reef site and zone (\pm SE) as recorded in video belt transects off Port Everglades in March 2006.	49
Figure 24.	Total fish abundance at each site (\pm SD) as recorded in fish censuses conducted off Port Everglades in March 2006.	54
Figure 25.	Total fishes by size class at each site surveyed (\pm SD) as recorded in fish censuses conducted off Port Everglades in March 2006.	54
Figure 26.	Relative location of Moyer et al.'s (2003) study sites "Corridor 3" and "Corridor 4" ; Gilliam et al.'s (2006) sites "FTL2" and "FTL3"; Gilliam's (2007) sites "BC2" and "BC3"; and sites R2, R3, R3-C, R3-PI in this study.	57

1.0 INTRODUCTION

1.1 Study Context and Objectives

The Jacksonville District U.S. Corps of Engineers (USACE) is conducting a feasibility study to evaluate the widening and deepening of the Outer Entrance Channel (OEC) of Port Everglades Harbor (Broward County, Florida). The proposed OEC improvements would impact offshore reef communities associated with two shore-parallel fossil reefs. Mapping of these reef habitats and a quantitative assessment of affected biota was required to determine the biological community characteristics of possible impact areas. The *amount* and *type* of mitigation required, should the project result in unavoidable impacts, will be calculated using these data, but will be addressed in a separate Habitat Equivalency Assessment (HEA) Report and Mitigation Plan.

The USACE contracted Dial Cordy and Associates Inc. (DC&A) to map benthic habitats and assess population levels of reef biota using standardized survey techniques. The principal objective of the study was to quantitatively describe, using parametric and non-parametric statistics, the sessile organisms (i.e., macroalgae, sponges, octocorals and hard corals) and reef fishes associated with the two fossil reefs that are likely to be directly or indirectly impacted. Study sites included reef habitats within, adjacent to, and south of, the area subject to proposed OEC improvements (see “Dredge Limits of Proposed Outer Entrance Channel” in Figure 1).

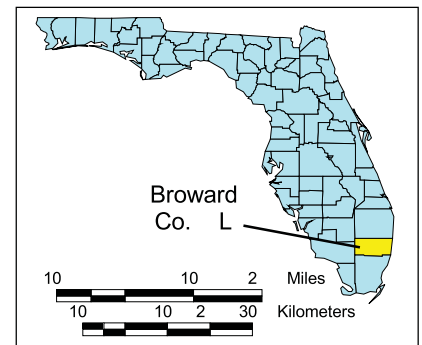
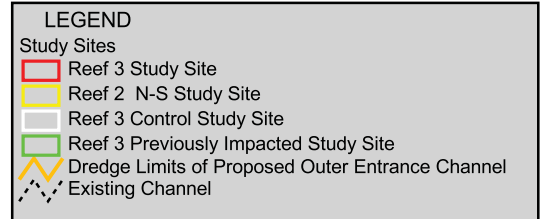
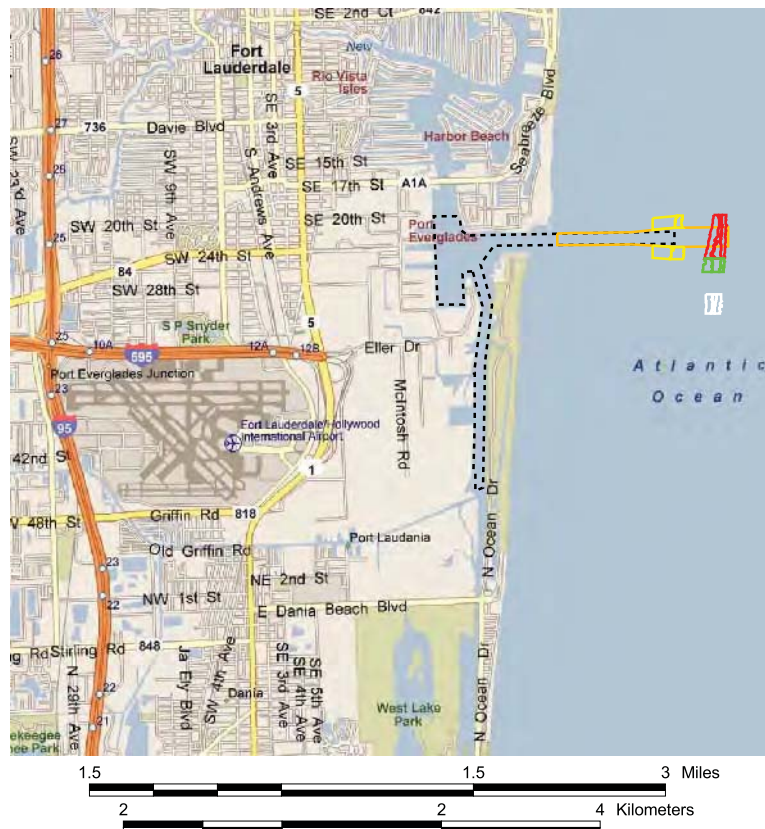
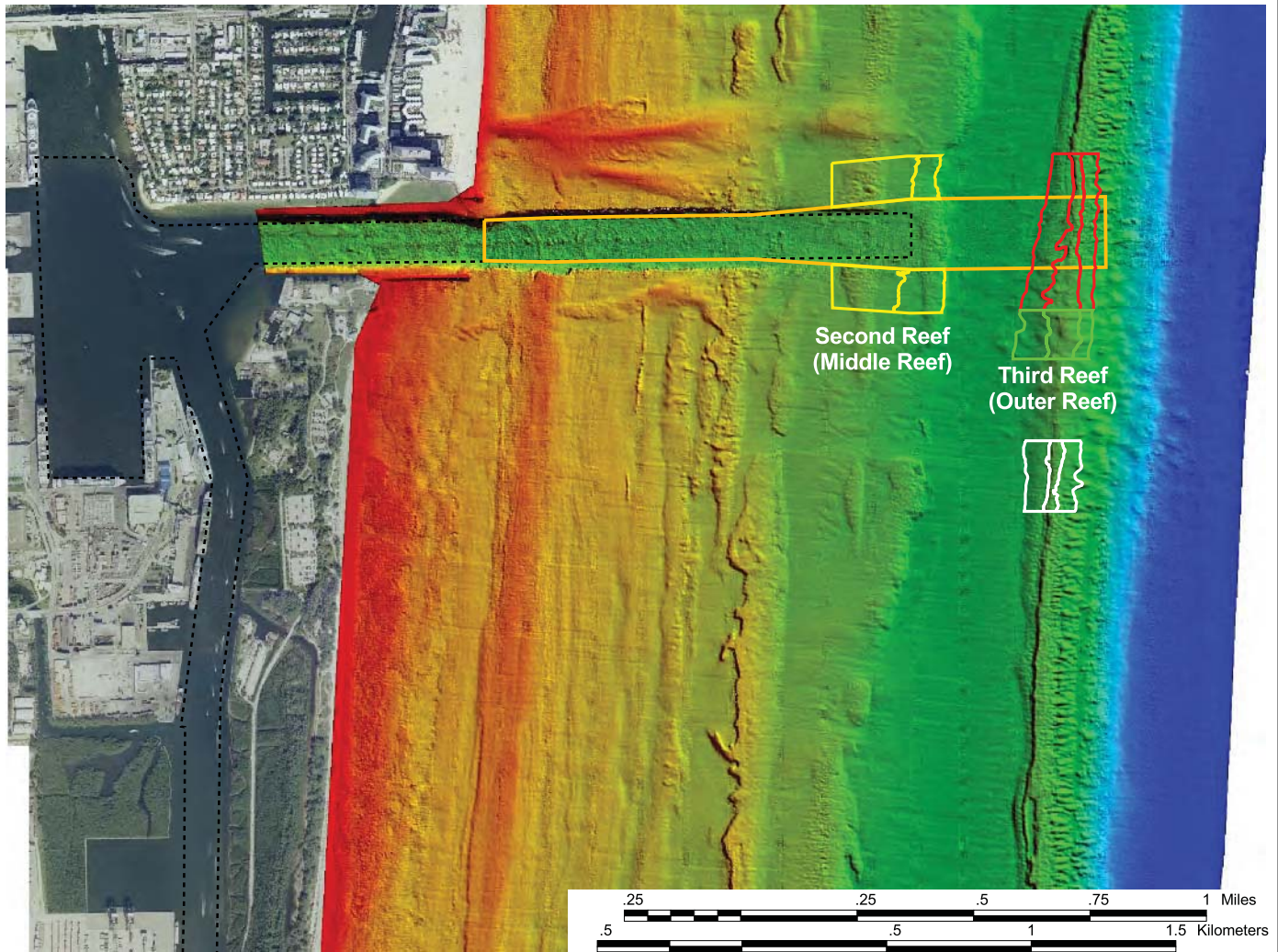
1.2 Study Area

The reef tracts of southeast Florida (Miami-Dade, Broward, and Palm Beach counties) are considered high-latitude reefs, existing near the northern limit of reef growth in the continental United States (e.g., Goldberg 1973). The study area was located on a portion of the reef complex that lies seaward of Port Everglades, Broward County, Florida (see Goldberg 1973; Moyer et al. 2003; Gilliam et al. 2004 and 2006; Banks et al. 2007). The complex is comprised of a nearshore hardbottom zone and a seaward succession of three shore-parallel reefs referred to as the “inner,” “middle,” and “outer” reefs, or the “first,” “second,” and “third” reefs, respectively (Goldberg 1973; Moyer et al. 2003; Gilliam et al. 2004, 2006; Banks et al. 2007). This reef system is established on mid-Holocene fossil-reefs, formed by elkhorn coral communities that were subsequently drowned by sea level rise between 5000 and 7000 years ago (Lighty et al. 1978). The reef-fossil substrates currently support modern biological communities consisting of Caribbean fauna (Moyer et al. 2003; Gilliam et al. 2004, 2006). Surveys for this study were conducted on the two outermost fossil reefs (middle and outer reefs) in water depths ranging from approximately 8 to 21 m. In this report, the outer reef is also referred to as “third reef,” and the middle reef as “second reef.” Neither the shoreward hardbottom zone nor the inner reef was investigated since the scope of work did not include these areas.

The reef complex found offshore Port Everglades is highly variable in terms of spatial distribution of its biological communities (Moyer et al. 2003) and does not conform to the classic reef zonation described for tropical and sub-tropical reef systems (Goreau 1959; Stoddart 1969; Loya 1972; Goldberg 1973). Numerous factors, such as seasonally cold ocean water, tidal inlet discharge, groundwater seepage, freshwater inputs and high variability of substratum complexity and composition have been proposed to explain why benthic communities of high latitude reefs off Florida differ from typical reefs of the western Atlantic region (Goldberg 1973). Although no longer a growing, or accreting reef system as it once was 5000 to 7000 years ago (Banks et al. 2007), the reef complex provides storm protection, habitat for invertebrates and fish species, and recreational uses that result in economic benefits to South Florida (Johns et al. 2001).

The biological communities of the Broward County reef complex likely to be impacted by the OEC improvements are dominated by algae, octocorals, sponges, and, to a lesser extent, hard corals, which form a thin veneer on the underlying mid-Holocene fossil-reef system (Goldberg 1973; Moyer et al. 2003; Gilliam et al. 2004; 2006; Banks et al. 2007; this study).

For the purposes of this report, general characteristics and discussion of other authors' data will refer to second and third reefs, unless specific sites are referenced. The terms "Reef 2" and "Reef 3" refer specifically to the study sites surveyed and any data collected during this study in 2006. "Reef 2," also R2, is the study site located on the second reef and includes both north and south survey areas. There are three geographically distinct sites located on the third reef: (1) Reef 3 (R3), (2) Reef 3 Previously Impacted (R3-PI), and (3) Reef 3 Control (R3-C). Unless otherwise specified, "Reef 3" refers to the potential impact area for the proposed OEC improvement (the northernmost site on the third reef). The selection of study sites (described in Section 2.3.1) on the second and third reefs (Figure 1) were guided by USACE, based on proposed study design and study objectives as outlined above. Figure 2 shows a conceptual schematic of the OEC improvements under consideration.



Location of Study Sites

Benthic and Fish Community Assessment at Port Everglades Harbor Entrance Channel

Scale: 1 inch as shown

Drawn by: MR

Date: August 2

Approved by: C



05- 5

Figure 1

2.0 METHODS

2.1 Initial Benthic Habitat Mapping

Prior to the initiation of the on-site quantitative assessment, reef habitats were mapped/plotted using the latest data available including Laser Airborne Depth Sounder (LADS) information; Light Detection and Ranging (LIDAR) bathymetric information; acoustic bathymetric data; the most recent, high-resolution, color aerial photography; and geographic positioning system (GPS) integrated, towed, video survey data. The video surveys were conducted in the OEC and on the reef system in the proposed OEC improvement area in 2000, 2001, and 2002. These videos provided additional qualitative information of habitats within the study area.

Data were synthesized using ArcView Geographic Information System (GIS) software, which was subsequently used to generate habitat maps of the study sites. Maps were created in both two and three dimensions to assist in planning field operations and to characterize the reef habitats. The three-dimensional images created were also used to visualize the potential impacts of proposed OEC improvements on the existing reef structure.

2.2 Benthic Habitat Reconnaissance

Following desktop mapping efforts, field reconnaissance was conducted to identify habitat types of the reef system. The DC&A project team conducted multiple dives in each of the areas to be studied on the second and third reefs between February 14 and 22, 2006. Dive locations were selected from the information obtained during the desktop mapping effort. Visual observations and videographic data of the field reconnaissance provided information on the biological characteristics of the second and third reefs. Depth data were groundtruthed. Benthic cover type, the abundance of organisms, and the depths at which these occurred were used to define zonation patterns for the Study Design.

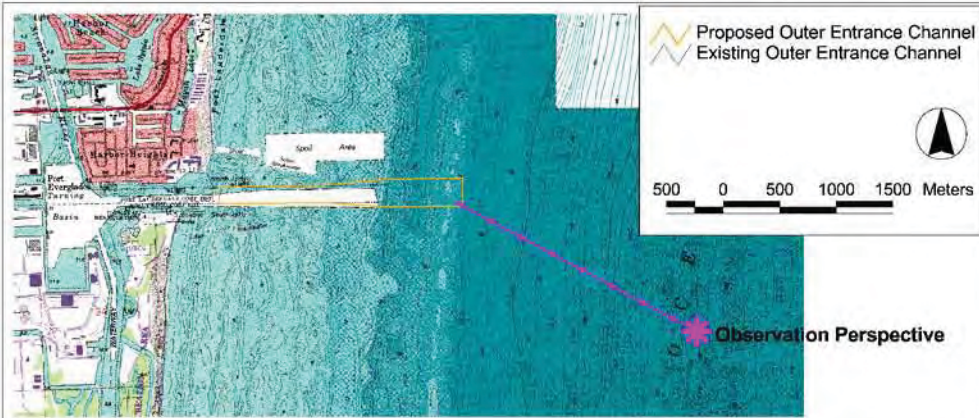
2.3 Quantitative Benthic Community Assessment

2.3.1 Study Design

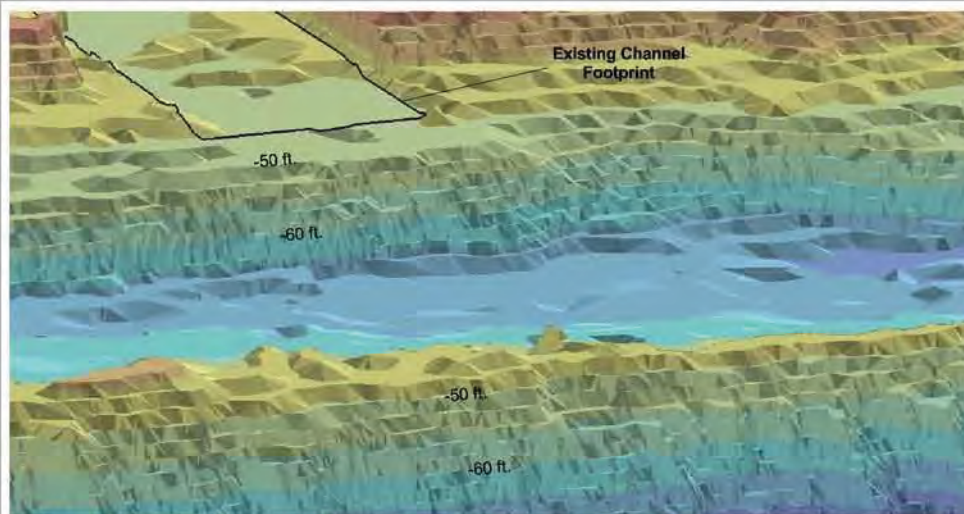
Study sites were located on the second reef and third reefs. The hierarchical sampling scheme is shown in Table 1. Reef 2 was a single study site consisting of: Reef 2 North (R2 North) and R2 South, relative to the OEC (Figure 3). Three study sites were located on the third reef: Reef 3 (R3) (located within the footprint of the proposed extension of the OEC), R3 Previously Impacted (R3-PI) (located to the south of R3), and R3 Control (R3-C) (located to the south of R3 Previously Impacted) (Figure 3). The R3-PI study site is most likely the result of impacts caused by the dumping of material (likely dredge spoil) of size ranging from pebbles to boulders (personal communication, Richard Dodge, NOVA Southeastern University, Fort Lauderdale, FL). Each study site was subdivided into zones. There were two biological zones at R2, three at R3, three at R3-PI, and three at R3-C (Figure 3). In each zone, 12 to 16 replicate belt transects and fish assessments were conducted at two to four random points (Figures 4, 5, 6; Table 1).

Table 1. Sampling hierarchy, Port Everglades benthic assessment, March 2006

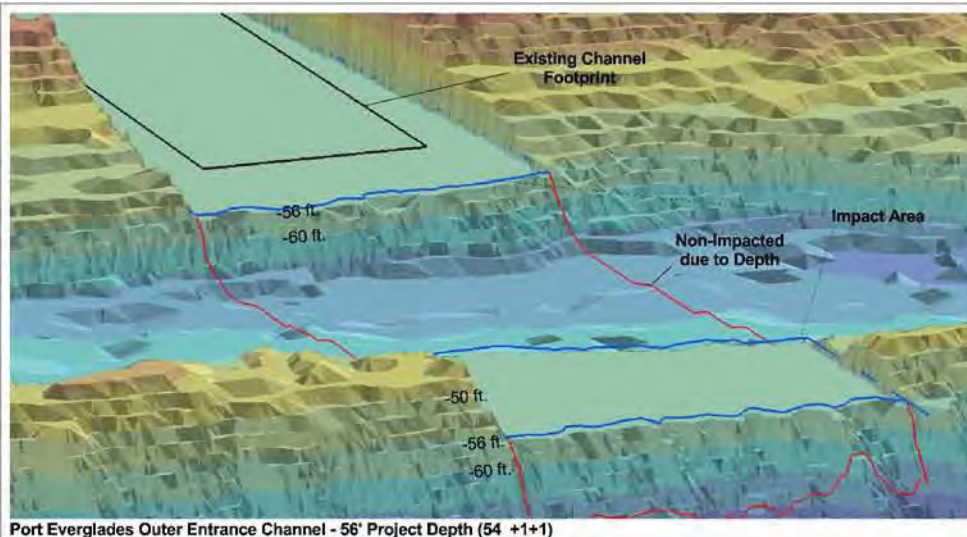
Sampling Hierarchy	Port Everglades										
Reefs	Second Reef		Third Reef								
Study Sites (n=4)	Reef 2 (R2)		Reef 3 (R3)			Previously Impacted (R3-PI)			Control (R3-C)		
Zones (n=11)	Zone 1	Zone 2	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
Sampling Points (Random Points) (n=41)	4	4	4	4	4	3	3	3	4	4	4
Replicate Transects (n=159)	15	16	16	16	14	12	12	12	16	16	14



Port Everglades Outer Entrance Channel (Plan View)



Port Everglades Outer Entrance Channel - Existing Conditions (2 foot contour interval, 10x vertical exaggeration)



Port Everglades Outer Entrance Channel - 56' Project Depth (54' +1+1)

gl

Benthic and Fish Community Assessment at Port Everglades Harbor Entrance Channel

So : howno

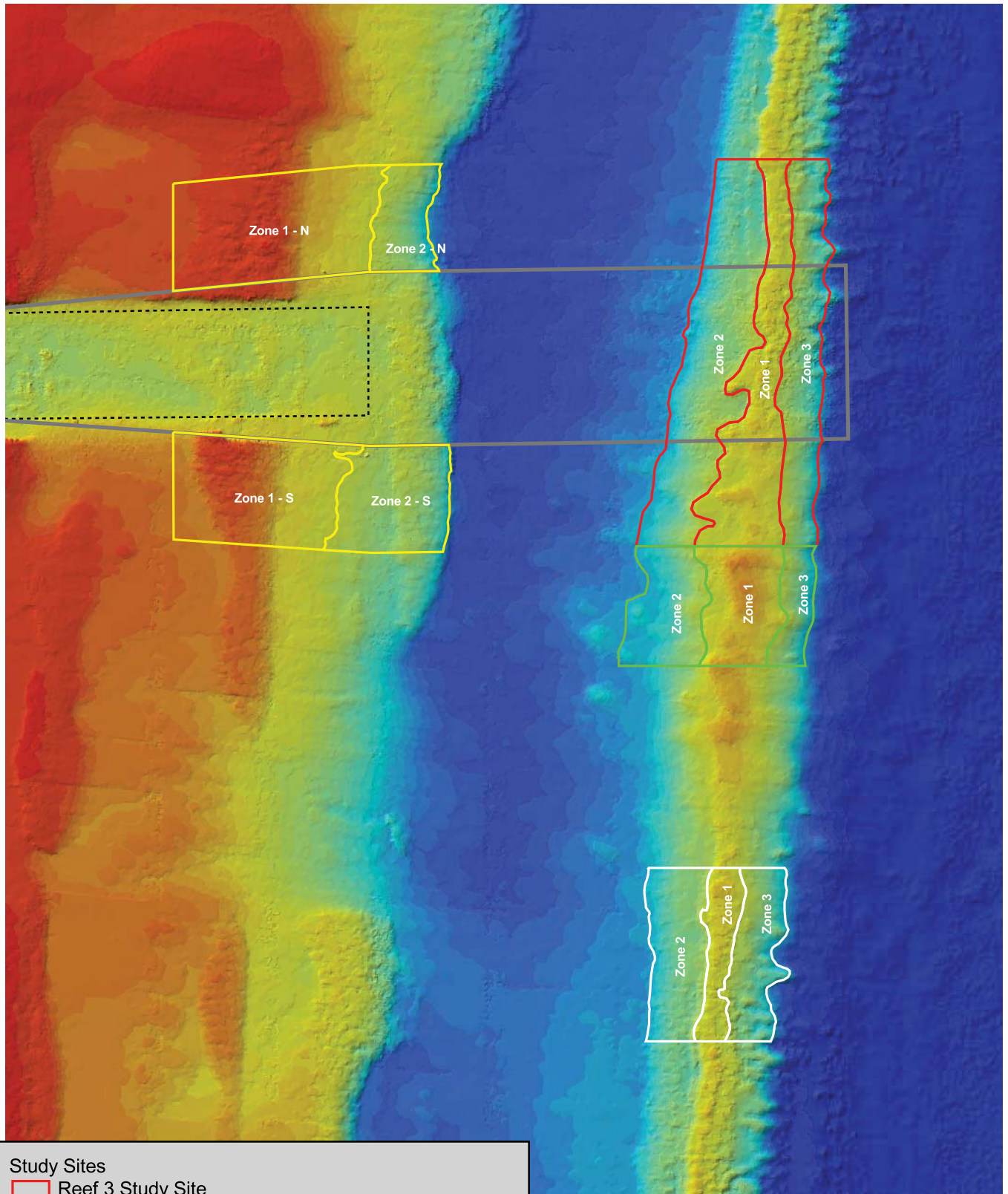
Dr wn By: MR

Do : ugus 20 8o

By: Co



Figur 2



Study Sites

- Reef 3 Study Site
- Reef 2, N-S Study Site
- Reef 3 Control Study Site
- Reef 3 Previously Impacted Study Site
- Proposed Outer Entrance Channel
- Existing Outer Entrance Channel



100 0 100 200 300 400 Meters

250 0 250 500 750 1000 1250 1500 Feet

Reef Study Zones

Benthic and Fish Community Assessment at Port Everglades Harbor Entrance Channel

Scale: 1 inch = 200 meters

Drawn by: MR

Date: August 2009

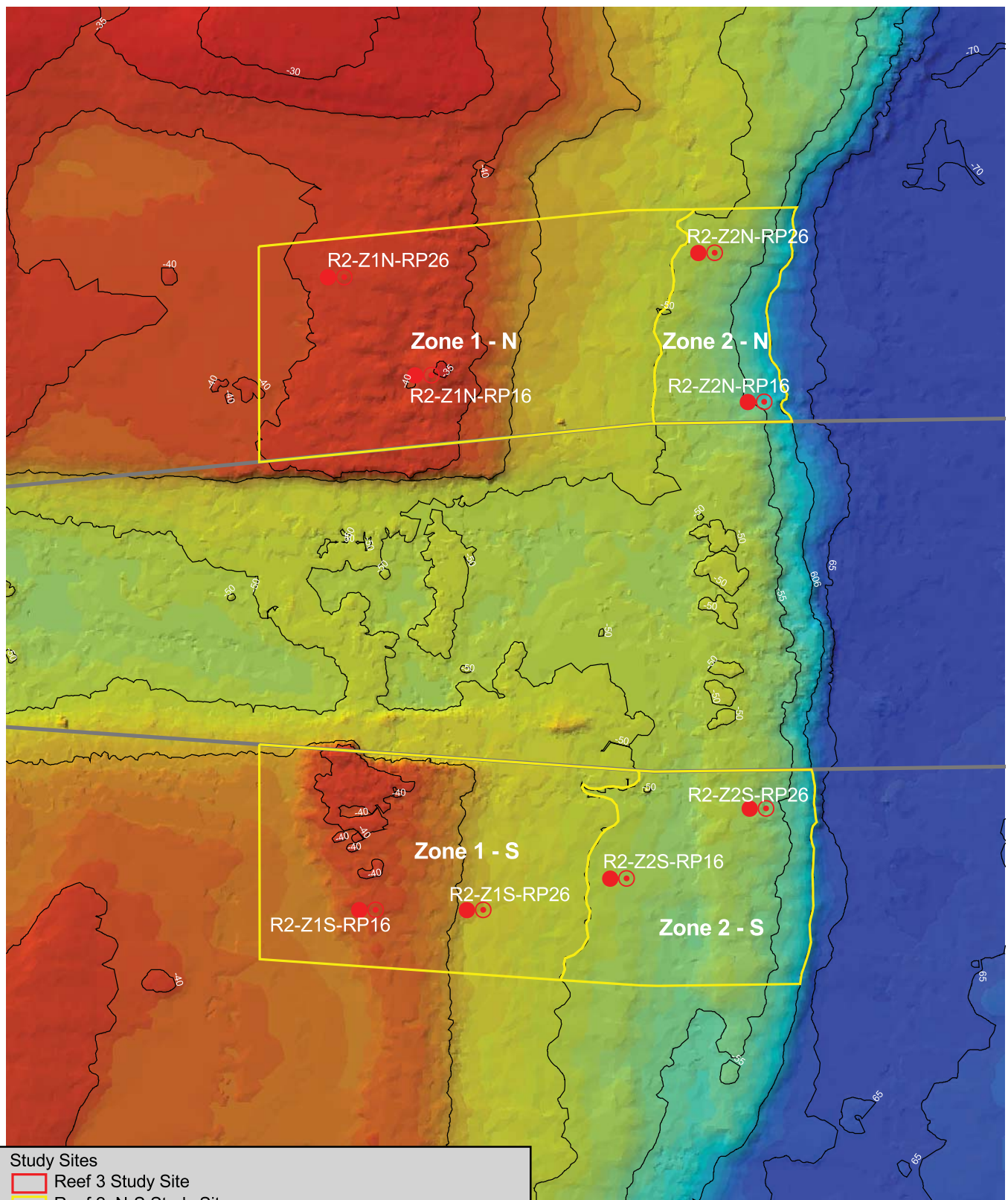
Approved by: C



**DIAL CORDY
AND ASSOCIATES INC.**
Environmental Consultants

J05-905

Figure 3



Study Sites

- Reef 3 Study Site
- Reef 2, N-S Study Site
- Reef 3 Control Study Site
- Reef 3 Previously Impacted Study Site
- Random Points for Transect Locations
- Proposed Outer Entrance Channel
- Contour (5 ft Interval)



1006 06 1006 200 Meters

2506 06 2506 5006 750 Feet

Random Points for Transect Locations Reef 2 Site6

Benthic and Fish Community Assessment
at Port Everglades Harbor Entrance Channel

Scale 1 inch 100 meters

rawn BY MR6

ate August 2008

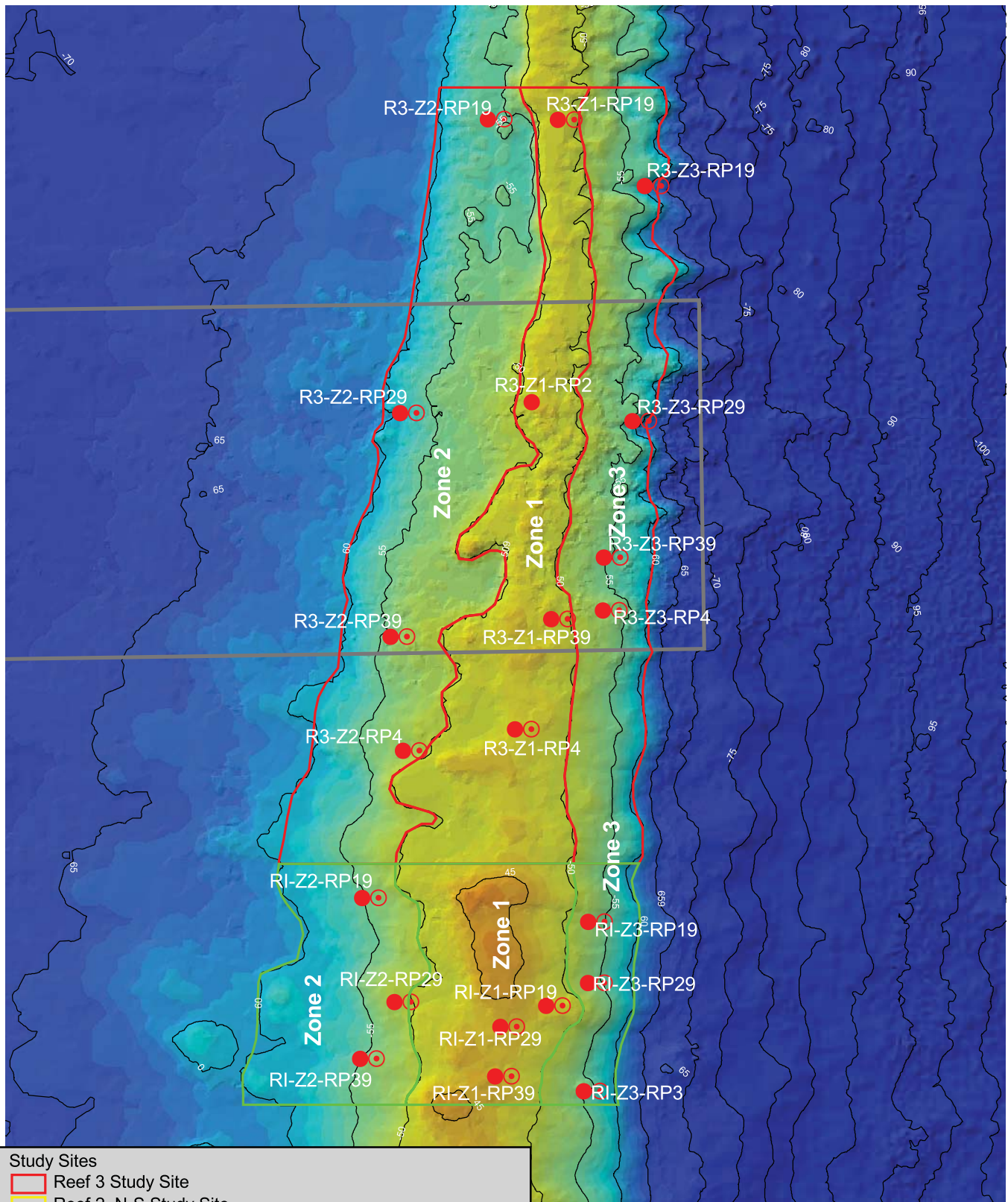
Approved By: C



DIAL CORDY
AND ASSOCIATES INC.
Environmental Consultants

J05- 056

Figure 46



- Study Sites**
- Reef 3 Study Site
 - Reef 2, N-S Study Site
 - Reef 3 Contro Study Site
 - Reef 3 Previously Impacted Study Site
 - Random Points for Transect Locations
 - Proposed Outer Entrance Channel
 - Contour (5 ft Interval)



1009 09 1009 200 Meters

2509 09 2509 5009 750 Feet

Random Points for Transect Locations Reef 3 Site

Benthic and Fish Community Assessment
at Port Everglades Harbor Entrance Channel

Scale 1 inch = 100 meters

rawny9MR

ate: ugust 2008

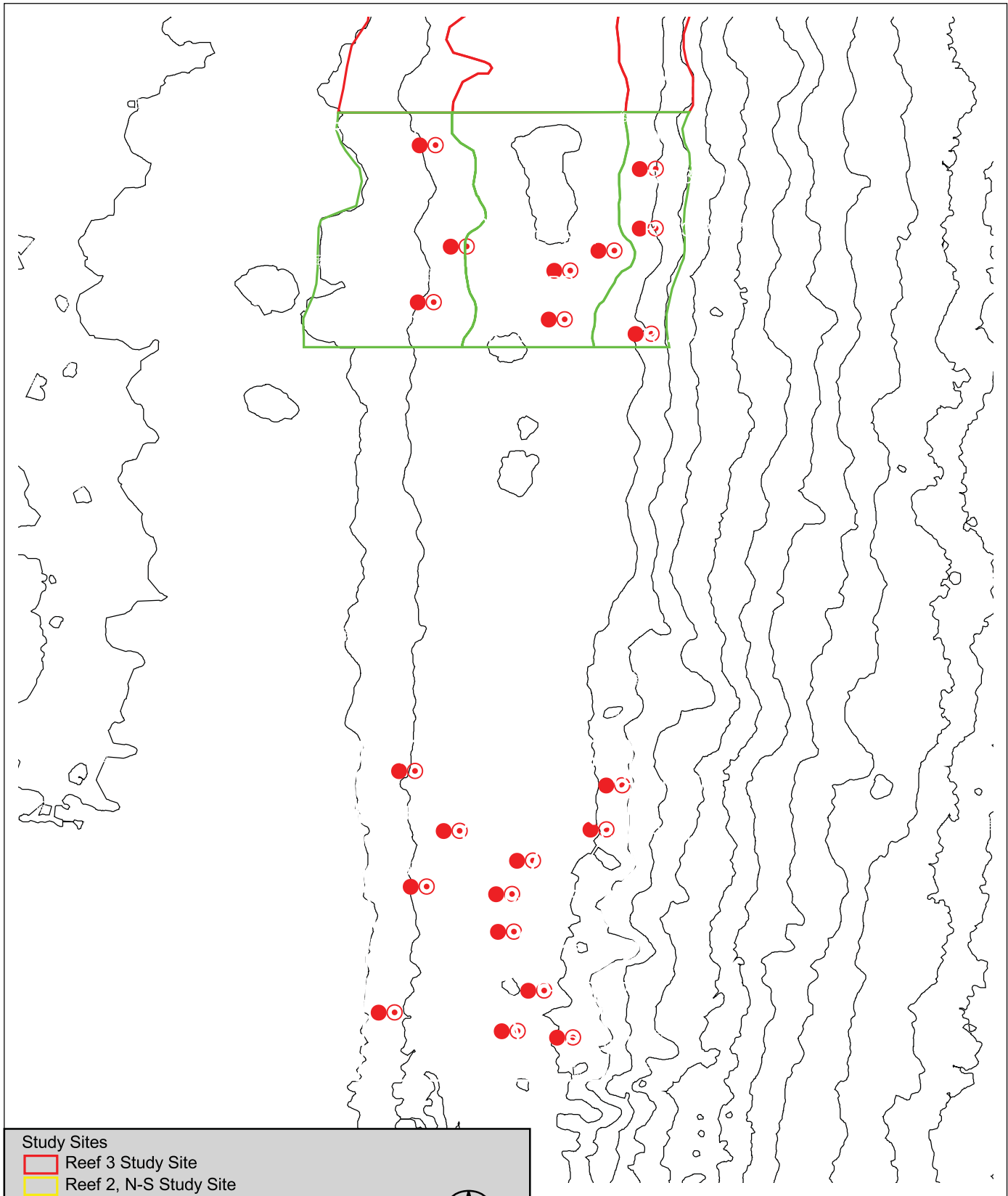
pproved y: C



**DIAL CORDY
AND ASSOCIATES INC.**
Environmental Consultants

J05- 059

Figure 59




Study Sites

- Reef 3 Study Site
- Reef 2, N-S Study Site
- Reef 3 Control Study Site
- Reef 3 Previously Impacted Study Site
- Random Points for Transect Locations
- Proposed Outer Entrance Channel
- Contour (5 ft interval)

1007 07 1007 200 Meters

2507 07 2507 500 750 Feet

Random Points for Transect Locations Control and Previously Impacted Sites	
Benthic and Fish Community Assessment at Port Everglades Harbor Entrance Channel	
Scale 1 inch = 100 meters	Drawn by MR
Date: August 2008	Approved by: C
 DIAL CORDY AND ASSOCIATES INC. Environmental Consultants	J05-057
	Figure 67

The zonation of second and third reef study sites was established based on the abundance of sessile benthic organisms, water depth, and seafloor topography. The depth of the second reef study site (Reef 2) ranged from 15 m (45 ft) to 18 m (60 ft). Between 15 and 16 m octocorals were higher in abundance than sponges, while between 16 and 18 m sponges were more abundant than octocorals. The difference in abundance of benthic organisms indicated a biological zonation of the reef. Zone 1 was assigned to the shoreward 15 m to 16 m area, while Zone 2 was contained within the 16 m to 18 m depth range. The sizes of Reef 2 zones are shown in Table 2.

The depth of third reef study sites ranged from approximately 13 m (43 ft) to 19 m (60 ft). The shallowest part of the third reef formed a ridge running along the north-south axis of the tract. Between 13 and 15 m, the ridge supported a biological community with more octocorals, sponges, and scleractinians compared to either slope (i.e., between 14 and 19 m). The difference in abundance of benthic organisms indicated a biological zonation of the reef: Zone 1 was assigned to the ridge area contained between 13 and 15 m; Zone 2 was assigned to the shoreward slope of the ridge (16 to 19 m), and Zone 3 to the seaward slope (16 to 19 m). Sand and rubble bordered Zone 2 and a large progressively deeper hardbottom area bordered Zone 3. Reef 3 zone surface areas ranged from 2.8 to 4.6 ha (7.0 to 11.4 ac), Reef 3 Control zones ranged from 1.0 to 1.9 ha (2.4 to 4.7 ac), and Reef 3 Previously Impacted zones ranged from 0.8 to 1.8 ha (1.9 to 4.4 ac) (Table 2; Figures 4, 5, and 6). Further, The DC&A preliminary surveys of these sites revealed that live cover was discontinuous and interrupted by numerous patches of rubble and barren areas of hardbottom. This observation suggested that an adequate representation of each zone would necessitate a potentially large number of samples randomly scattered within each zone.

Table 2. Sizes of study sites surveyed off Port Everglades, Florida

Study Site	Zone	Area (ha)	Area (ac)
Reef 2	Zone 1	7.8	19.3
	Zone 2	3.5	8.7
Reef 3	Zone 1	3.3	8.2
	Zone 2	4.6	11.4
	Zone 3	2.8	7.0
Reef 3 – Control	Zone 1	1.0	2.4
	Zone 2	1.9	4.7
	Zone 3	1.6	3.9
Reef 3 – Previously Impacted	Zone 1	1.8	4.4
	Zone 2	1.7	4.2
	Zone 3	0.8	1.9

2.3.3 Sampling Design

The objectives of the quantitative benthic survey were to assess (1) the composition, density, size, coverage, and condition of benthic organisms (including scleractinians, octocorals, sponges, zoanths, and macroalgae); and (2) the extent of bare substrate and unconsolidated substrate (sand, rubble). The methods used to assess the benthic organisms included both *in situ* visual assessments and videographic capture and point-count analysis conducted along belt transects (Aronson et al. 1994; Aronson and Precht 1995; Aronson and Swanson 1997; Murdoch and Aronson 1999; Aronson et al. 2005). Individual belt transects were 10 m long and 1 m wide for

the visual assessments, and 10 m long and 0.4 m wide for video transects. The dimensions of individual belt transects were based on methods applied to coral reefs in Florida and the Caribbean (e.g., Loya 1976; Rogers et al. 1983; Liddell et al. 1984; Aronson and Precht 1995).

DC&A applied a random sampling design to each zone. DC&A established up to four random sampling stations in each zone from which four non-contiguous 10 m long replicate belt transect surveys were conducted. This was done to achieve maximum scatter within a zone and within sampling stations. A permanent marker (steel rod) was driven into the hardbottom to mark the location of each station. A weighted float was placed immediately above the station marker so that the Differential Global Positioning System (DGPS) geographic coordinates of the station could be acquired.

The randomization of sampling stations was done using the random point ("RP") generator V1.3 for ArcView GIS. At each sampling station, the origins of replicate transects were set at random distances between 1 and 5 m from the station marker. Random distances were selected from a table of random numbers (Rohlf and Sokal 1969). At each sampling station, the direction of the first transect was random (compass headings were selected randomly between 000 and 360 from a table of random numbers; Rohlf and Sokal [1969]). The second transect was perpendicular (90°) to the first transect, and so on. Transects were numbered in a clockwise manner. Figures 4, 5, and 6 illustrate the locations of the sampling stations. Table 3 lists the geographic coordinates of each sampling station per site and zone, the random heading of transect 1 at each sampling station and the random distances of transects from the sampling station.

Transect data at a given sampling station were pooled since the placement of transects around a common origin caused the transects to be dependent replicates. Since up to four 10 m long transects radiated from each sampling station, the total maximum area surveyed per station (or per sampling point) during *in situ* visual surveys was 40 m², and 16 m² for video surveys. A given reef zone totaled a maximum of 160 m² of *in situ* visual surveys and 64 m² of video surveys.

After the field portion of this study had been planned and conducted, it was brought to DC&A's attention that the boundaries of the Reef 3 Previously Impacted area selected in this study may have been underestimated. Specifically, the southernmost sampled areas within Reef 3 Zones 1 and 2 (R3-Z2-RP4 and R3-Z1-RP4) were possibly within the previously impacted area, as were the five northernmost points in the Reef 3 Control areas (i.e., R3C-Z1-RP1, R3C-Z2-RP1, R3C-Z2-RP2, R3C-Z3-RP1, and R3C-Z3-RP2) (personal communication Richard Dodge, NOVA Southeastern University, Ft. Lauderdale, Florida).

In total, from March 14 to March 26, 2006, the DC&A project team assessed the benthos at 41 random sampling stations (points) and 159 transects at Reef 2 and third reef sites (Figure 3; Table 4). Control data for Reef 2 were voluntarily not acquired since representatives of state and federal agencies, and regional experts agreed that DC&A could use pre-existing information on Reef 2 sites for comparisons (e.g., Gilliam et al. 2006).

Table 3. DGPS locations of random sampling stations (points), random bearing of each belt transect (T), and the distance used to locate the origin of belt transects away from station markers

Sampling Point	Longitude	Latitude	Bearing T1	Bearing T2	Bearing T3	Bearing T4	Distance from Pin (m)			
R3-C-Z1-RP1	80 05 05.11188	26 05 11.45211	237	327	57	147	2	3	5	4
R3-C-Z1-RP2	80 05 05.65536	26 05 10.67314	275	5	95	185	3	5	5	3
R3-C-Z1-RP3	80 05 05.60730	26 05 09.80128	290	20	110	200	1	1	1	3
R3-C-Z1-RP4	80 05 05.53766	26 05 07.47339	235	325	55	145	3	2	1	4
R3-C-Z2-RP1	80 05 08.14452	26 05 13.56109	45	135	225	315	5	2	2	4
R3-C-Z2-RP2	80 05 06.99285	26 05 12.15732	5	95	185	275	2	4	1	1
R3-C-Z2-RP3	80 05 07.85838	26 05 10.86538	211	301	31	121	3	2	1	1
R3-C-Z2-RP4	80 05 08.71474	26 05 07.92931	193	283	13	103	2	5	5	4
R3-C-Z3-RP1	80 05 02.79512	26 05 13.19042	53	143	233	323	4	3	2	4
R3-C-Z3-RP2	80 05 03.20892	26 05 12.16303	314	44	134	224	5	5	4	4
R3-C-Z3-RP3	80 05 04.85031	26 05 08.41982	217	307	37	127	5	3	2	2
R3-C-Z3-RP4	80 05 04.11302	26 05 07.32570	116	206	296	26	1	5	3	3
R2-Z1N-RP1	80 05 28.95607	26 05 42.65196	331	61	151	241	3	5	5	3
R2-Z1N-RP2	80 05 31.12151	26 05 44.89400	273	3	93	183	1	1	1	3
R2-Z1S-RP1	80 05 30.45397	26 05 30.48934	233	323	53	143	3	3	2	1
R2-Z1S-RP2	80 05 27.73397	26 05 30.47221	43	133	223	313	1	4	4	3
R2-Z2N-RP1	80 05 20.55932	26 05 41.98495	322	52	142	232	5	1	5	1
R2-Z2N-RP2	80 05 21.78337	26 05 45.38975	168	258	348	78	4	1	3	4
R2-Z2S-RP1	80 05 24.12000	26 05 31.17242	56	146	236	326	2	3	5	2
R2-Z2S-RP2	80 05 20.59806	26 05 32.73483	28	118	208	298	1	2	3	2
R3-Z1-RP1	80 05 02.43165	26 05 45.78223	356	86	176	266	4	4	5	2
R3-Z1-RP2	80 05 03.13963	26 05 39.37883	117	207	297	27	1	2	5	1
R3-Z1-RP3	80 05 02.69537	26 05 34.45372	0	90	180	270	2	3	3	2
R3-Z1-RP4	80 05 03.61424	26 05 31.95383	57	147	237	327	4	4	2	1
R3-Z2-RP1	80 05 04.19735	26 05 45.81325	359	89	179	269	3	4	1	2
R3-Z2-RP2	80 05 06.45387	26 05 39.15226	243	333	63	153	1	1	4	1
R3-Z2-RP3	80 05 06.73468	26 05 34.07328	306	36	126	216	5	3	3	3
R3-Z2-RP4	80 05 06.44776	26 05 31.47661	335	65	155	245	2	5	5	4
R3-Z3-RP1	80 05 00.26073	26 05 44.26303	125	215	305	35	2	1	3	3
R3-Z3-RP2	80 05 00.60936	26 05 38.93689	107	197	287	17	2	5	1	5
R3-Z3-RP3	80 05 01.35739	26 05 35.84169	324	54	144	234	3	5	5	1
R3-Z3-RP4	80 05 01.38874	26 05 34.63360	38	128	218	308	1	3	1	2
R3-PI-Z1-RP1	80 05 02.89546	26 05 25.66022	87	177	267	357	2	5	4	4
R3-PI-Z1-RP2	80 05 04.03971	26 05 25.20199	243	333	63	153	1	4	2	5
R3-PI-Z1-RP3	80 05 04.19107	26 05 24.07390	147	237	327	57	3	3	2	3
R3-PI-Z2-RP1	80 05 07.50468	26 05 28.14566	125	215	305	35	1	3	4	5
R3-PI-Z2-RP2	80 05 06.71141	26 05 25.78347	147	237	327	57	1	5	3	2
R3-PI-Z2-RP3	80 05 07.57696	26 05 24.49153	58	148	238	328	2	5	5	3
R3-PI-Z3-RP1	80 05 01.81672	26 05 27.56485	73	163	253	343	4	5	3	5
R3-PI-Z3-RP2	80 05 01.83848	26 05 26.17842	36	126	216	306	1	2	4	3
R3-PI-Z3-RP3	80 05 01.95640	26 05 23.71307	280	10	100	190	2	5	5	4

Table 4. Reef site-zone, sampling point, number of samples and corresponding sampled area of visual and videographic transects conducted off Port Everglades in March 2006 [R=Reef; Z=Zone; P=Previously Impacted; C = Control; N=North; S=South; RP=Random Point]

Reef Site-Zone	Sampling Point	Visual Transects N	Visual Transects Area (m ²)	Video Transects N	Video Transects Area (m ²)
R2-Z1	N-RP1	4	40	4	16
	N-RP2		40		16
	S-RP1		40		16
	S-RP2		20		12
R2-Z2	N-RP1	4	40	4	16
	N-RP2		40		16
	S-RP1		40		16
	S-RP2		40		16
R3-Z1	RP1	4	40	4	16
	RP2		30		16
	RP3		40		16
	RP4		40		16
R3-Z2	RP1	4	40	4	16
	RP2		30		16
	RP3		40		16
	RP4		40		16
R3-Z3	RP1	4	40	4	16
	RP2		40		16
	RP3		30		16
	RP4		20		8
R3-PI-Z1	RP1	3	40	3	16
	RP2		40		16
	RP3		40		16
R3-PI-Z2	RP1	3	40	3	16
	RP2		40		16
	RP3		40		16
R3-PI-Z3	RP1	3	40	3	16
	RP2		40		16
	RP3		40		16
R3-C-Z1	RP1	4	40	4	16
	RP2		40		16
	RP3		40		16
	RP4		40		16
R3-C-Z2	RP1	4	20	4	16
	RP2		40		16
	RP3		40		16
	RP4		40		16
R3-C-Z3	RP1	4	40	4	16
	RP2		40		16
	RP3		20		16
	RP4		40		8

2.3.3.1 Visual Assessment of Benthos

The DC&A project team conducted visual assessments of the benthos 50 cm on either side of a 10-m transect tape loosely draped on the seafloor. Visual assessments were typically done in sets of four transects [four transects per sampling station (or per random point (RP))]. A work sheet printed on underwater paper was used to record data on scleractinians and hydrocorals (species richness, maximum diameter per colony, number of colonies per species, condition of each colony), octocorals (list of genera, maximum height per colony, number of colonies per genus), sponges (list of genera, number of *Xestospongia muta* colonies, maximum height per *X. muta* colony), zoanthids (number of colonies, maximum diameter per colony), algae (list of genera), substrate type, sediment depth, and the maximum height of the substrate relief. The size classes of scleractinians were pre-assigned as follows: Class I = 0-3 cm; Class II = 4-10 cm; Class III = 11-25 cm; Class IV = 26-50 cm. The size classes of octocorals were pre-assigned as well: Class I = 0-10 cm; Class II = 11-25 cm; Class III = 26-50 cm; Class IV = > 50 cm. The data collected during the visual assessments are included in Appendix A.

Quality Assurance/Quality Control (QA/QC) for the visual assessment method was done in the field before the belt transect data collection. The goal of the QA/QC was to achieve the highest possible agreement between observers (less than 10% error). A total of three marine scientists participated in the visual assessment and the QA/QC process at the onset of the fieldwork. Each of the three observers independently recorded the identification and size of the same scleractinians and octocorals along the same transects. Individual specimens were labeled by assigning a sequential number, which was written on an underwater etch-a-sketch pad. Photographic voucher samples were taken of specimens, including the specimen number. These photographs were later used to address discrepancies between observers. Discrepancies were discussed and consensus was reached. This was carried on at three separate transects until divers were in agreement 90% of the time. It is likely that the high level of agreement was partly due to the low diversity in this general area.

Scleractinian species diversity based on data collected in visual belt transects was calculated using the Shannon-Wiener diversity index (H'):

$$H' = -\sum_{i=1}^k p_i \log p_i$$

where k is the number of species present and p_i the proportion (n_i/N) of the i th species.

A model II ANOVA [single factor analysis of variance for a random effects model (Zar 1984)] was used to compare scleractinian species richness (S) and scleractinian colony density data between zones within and among reef sites. Differences between zones were further analyzed using the Tukey multiple means test (Zar 1984). To allow the valid application of parametric analyses of variance, data were transformed to make them normal, homoscedastic, and additive (Zar 1984; Aronson et al. 1994). Species richness and colony density values were logarithmically transformed (Zar 1984; Aronson et al. 1994). Species diversity data were not transformed because H' values were normally distributed (D'Agostino's test of departure from normality; Zar 1984). Differences between Shannon-Wiener diversity indices were tested using Hutcheson's (1970) t-test.

2.3.3.2 Videographic Assessment of Benthos

Given logistical constraints (including limited bottom time due to ship traffic, depth, visibility, and sea conditions), videography was preferred over photography as a method to acquire permanent and representative quantitative samples of benthos along belt transects. The video camera was placed in an underwater housing and fitted with a wide-angle lens. Videographic belt transects were recorded along 10 m-long measuring tapes draped over the hardbottom. At the beginning of each video transect, two panoramic landscape videos above the transect reference point were taken. First, the video camera was held at 30 degrees to the horizon and 1 m above the seafloor while the diver videotaped in a full circle around the transect reference point for 20 to 25 seconds. Second, the video camera was held 2 m above the bottom, parallel to the seafloor and recorded a full circle around the transect reference point for 20 to 25 seconds. A 40 cm swath of hardbottom on the left side of the 10 m transect from a height of 40 cm was videotaped using a digital video camera held perpendicular to the seafloor. The diver handling the video camera swam slowly (30 seconds per meter) along the entire length of each transect (including permanent reference marker and transect origin) to ensure that clear stop-action images for analysis were obtained. The camera was maintained at a constant height above the bottom using a pre-measured aluminum bar that projected forward from the camera. At the end of the bar was a depth gauge and scaling bar.

The stop-action images of the hardbottom measured 40 cm by 27 cm, or 1080 cm². The proximity of the camera lens to the hardbottom surface and the 4 mm resolution of the images allow the identification of hard corals down to a colony size of approximately 5 cm. Larger video frames would not allow this level of precision. The video transects were used to report on hard coral percent cover and species diversity; and percent cover of gorgonians, sponges, zoanthids, and macroalgae all of which were identified to the lowest practical taxonomic level.

Each video transect yielded approximately 25 stop-action images that were non-overlapping. Each stop-action image was processed via computer software (ULEAD). Hard coral, octocoral, hydrocoral (*Millepora alcicornis*), macroalgae, turf algae, sediment, and rubble percent cover, as well as species diversity for hard corals (expressed as species richness, S , and as the Shannon-Wiener Index, H'), were determined from video images. These parameters were estimated using the point-count software CPCe®. The adequate number of dots per video image and per transect was defined by examining changes in mean and standard deviation of percent cover and H' as a function of the number of dots per image and per transect. The adequate number of dots was 30 per image, and approximately 750 per transect, depending on the actual number of still images per transect. The data extracted from the videographic analysis are included in Appendix B.

QA/QC for the video method consisted of observers analyzing the same video transects and completing benthic component identification. Results were compared and observers were in agreement on 90% of point identifications along transects. The most discrepancies were found identifying small corals. The general category "coral" was used to avoid misidentification of scleractinian corals smaller than 3 cm in diameter.

Transects were treated as replicates within a zone, yielding an estimate of coral cover as well as other living and non-living (i.e., sand) benthic categories. Percent coverage was calculated for each transect from the resulting set of random points (RPs) generated using the CPCe® software. Data were collected on the point-counts of each coral species as well as various functional groups including octocorals, sponges, macroalgae, turf algae (>3 mm), and sand and rubble, (which were combined for statistical analysis as the non-living portion of benthic cover). Graphs were produced to allow the comparison of average percent cover of major substrate

types, including coral species, octocoral, sponge, macroalgae, and turf algae functional types, between and within sites.

The benthic percent cover data were statistically analyzed for significant differences among and between sites. The following benthic cover data categories were analyzed: scleractinian coral, *Millepora alcicornis*, octocorals, macroalgae, turf algae, sponge, sediment, and rubble. Diversity as measured by the Shannon-Weiner Index (H') was calculated for scleractinian corals.

All statistical tests were completed using SAS 9.1. First, the data were tested for normality. Since the data were not normal, they were transformed by the $\log(x+1)$ function and retested for normality using the Wilks-Shapiro test. After $\log(x+1)$ transformation the data were generally normally distributed. Data were analyzed using parametric and non-parametric methods. Data were first analyzed using the ANOVA Procedure (SAS). It was determined that the four transects associated with a given random point were generally similar, so these transects were pooled by random point for further analyses. ANOVAs were run which analyzed zones within sites and zones across sites for each taxonomic category. Zones were not pooled within sites because there were significant differences between zones within sites. Thus, models were run with zones nested within sites. In order to identify specifically which zones or sites were dissimilar from each other, Tukey multiple means tests were run simultaneously with the ANOVAs (Means/Tukey option in the ANOVA Procedure (SAS)). Pearson correlation coefficients were computed using the Corr Procedure (SAS). The coefficients were computed by site, by zone, and for each site/zone combination.

2.4 Fish Census

Fish censuses were conducted in conjunction with the quantitative benthic community assessment. A single trained fish biologist conducted all fish censuses. Two methods were employed: a point-count method following Bohnsack and Bannerot (1986) and belt transect method. Since many of the sampling stations were relatively close to one another, fish surveys were conducted at two of the four possible sampling stations per reef zone. This was done primarily to prevent pseudoreplication (Hurlbert 1984) especially for some of the more mobile fish species (e.g., trigger fishes, spade fish, snappers). Care was taken during each fish survey to note any potential reoccurrences of such highly mobile fauna. The locations of fish censuses were selected randomly using a table of random numbers (Rohlf and Sokal 1969). Fish identifications were made to the lowest taxon possible and total fish length was recorded. Humann (2005) was consulted to confirm fish identifications. Fish data were recorded on underwater paper and transferred to spreadsheets from which descriptive statistics were calculated.

Once a station marker was installed and the four transect tapes had been draped over the reef, point-count surveys were conducted at a 7.5 m distance from the end of the belt transects. Sixteen independent random point counts were conducted within each zone. A point count was conducted within an imaginary cylinder that had a 7.5 m radius and a height spanning from the seafloor to the sea surface. All species present within the cylinder were counted during the first five minutes. Thereafter the size classes and numbers of individuals of each species were recorded. Fish sizes were estimated using a 30 cm ruler attached to the end of a 1 m rod.

In addition to point counts, belt transect counts were conducted to capture small and cryptic species. At two sampling stations per reef zone, transect counts were conducted along each of the belt transects used for the benthic assessments. The data recorded included fish species, the abundances and sizes of fish found within a 1 m distance of the belt transect. A maximum of 40 m² were surveyed in this manner at each sampling station.

3.0 RESULTS

3.1 Benthic Survey – Visual Assessment

3.1.1 Sampling Site Characteristics

A large percentage of the seafloor cover (19%-57%) of the study sites consisted of bare substrate (consolidated and unconsolidated substrates). Hard substrate was typically interspersed by small sand pockets, shell hash, and areas of rubble (Table 5). There were, however, large sand flats at R2-Z2. The overall thickness of sand/shell hash ranged from 2 cm to more than 30 cm. Artificial substrates, though low in cover, were found within all belt transects, except R3-C-Z3. Most artificial substrates were small and had low relief. They included metallic cables, fishing line and weights, wood, rope, iron angle, and other metallic objects (Table 5). The artificial substrate with the greatest amount of vertical relief was cylindrical (27 cm high, 55 cm diameter) and was found within a belt transect at R2-Z1. Rocks, boulders, and sponges (in particular, *X. muta*) generated the greatest amount of relief among study sites. Maximum vertical relief varied from 0.45 to 1.50 m (Table 5).

Following are general descriptions of each of the sites by reef site, zone, and sampling station (i.e., random point, or “RP”):

Reef 2

- Zone 1, RP1: Hardbottom with sand/shell hash
- Zone 1, RP2: Desolate area, rubble, and some broken carbonate substrate
- Zone 1, RP3: Hardbottom, sand channel, and abundant sponges
- Zone 1, RP4: Hardbottom, abundant sand, rubble, human-made debris (wood, aluminum can), and high sedimentation
- Zone 2, RP1: Coarse sand, rubble, scattered rocks, and some bunched up cables
- Zone 2, RP2: Transects 1 and 2 contained a large sand flat (fine sand) abutting hardbottom. The substrate underlying transect 3 was characterized by hardbottom and small sand pockets
- Zone 2, RP3: Patchy hardbottoms interspaced by sand flats (fine sand and shell hash)
- Zone 2, RP4: Flat area of hardbottom and rubble.

Reef 3

- Zone 1, RP1: Hardbottom, little relief except for *X. muta*, fishing line encrusted by *Millepora alicornis*
- Zone 1, RP2: Hardbottom, rubble, rocks, small pockets of coarse sand
- Zone 1, RP3: Hardbottom, boulders, gravel
- Zone 1, RP4: Hardbottom with rubble and rocks, pockets of coarse sand, fine sediment covering the seafloor
- Zone 2, RP1: Hardbottom, rubble, rocks, and small coarse sand pockets
- Zone 2, RP2: Rubble and rocks
- Zone 2, RP3: Hardbottom, rubble, rocks, coarse sand, and artificial substrate (metal); RP4: Hardbottom, rocks, rubble, large rocks, coarse sand, and heavy sedimentation.

- = Zone 3, RP1: Hardbottom, rubble, rocks, and fine sand covering hard substrate
- = Zone 3, RP2: Hardbottom, and some artificial substrate (fishing line)
- = Zone 3, RP3: Hardbottom, rubble, rocks, and some artificial substrate (metallic cable)
- = Zone 3, RP4: Hardbottom and boulders

Reef 3, Previously Impacted

- Zone 1, RP1: Abundant turf, hardbottom, rocks, boulders, abundant rubble, coarse sand, artificial substrate (rope), and rubble found inside *X. muta*
- Zone 1, RP2: Abundant turf, hardbottom, rocks, rubble, coarse sand, and high sedimentation
- Zone 1, RP3: Hardbottom with boulders, rocks, rubble, and small pockets of coarse sand
- Zone 2, RP1: Hardbottom, rubble, scattered rocks, coarse sand
- Zone 2, RP2: Hardbottom, scattered rocks, rubble, coarse sand, and high sedimentation
- Zone 2, RP3: Hardbottom, scattered rocks, rubble, coarse sand, and artificial substrate (cable, brick, fishing line)
- Zone 3, RP1: Hardbottom, rocks, rubble, small pockets of coarse sand, abundant burrowing activity in rubble
- Zone 3, RP2: Hardbottom, rubble, rocks, coarse sand, burrowing activity, and artificial substrate (cable, fishing line)
- Zone 3, RP3: Hardbottom, coarse sand, boulders, rocks, and rubble

Reef 3, Control

- Zone 1, RP1: Hardbottom
- Zone 1, RP2: Hardbottom with sand patch
- Zone 1, RP3: Hardbottom with some sand, gravel, cobbles, and sand flat
- Zone 1, RP4: Scattered rocks with abundant turf cover, hardbottom, sand, and artificial substrate (fishing gear)
- Zone 2, RP1: Hardbottom with rubble and sand, high sedimentation, a cable runs through the site, abundant sponges
- Zone 2, RP2: Hardbottom, rock, rubble, loose rocks, coarse sand, and juvenile corals growing on loose rocks
- Zone 2, RP3: Hardbottom, rubble, and sand
- Zone 2, RP4: Coarse sand and hardbottom
- Zone 3, RP1: Hardbottom with rubble
- Zone 3, RP2: Hardbottom with rubble, coarse sand, high sedimentation
- Zone 3, RP3: Hardbottom with rubble, sand pockets, coarse sand
- Zone 3, RP4: Hardbottom with sand, and high sedimentation

Table 5. General substrate characteristics by reef site and zone off Port Everglades based on visual belt transects conducted in March 2006. Presence of a substrate is indicated by an “x.” [R =Reef; Z = Zone; PI = Previously Impacted; C = Control]

Reef Site	R2		R3			R3-PI			R3-C		
Zone	Z1	Z2	Z1	Z2	Z3	Z1	Z2	Z3	Z1	Z2	Z3
Bare Substrate Cover (%)	30	57	19	29	32	35	49	41	28	32	33
Hardbottom	x	x	x	x	x	x	x	x	x	x	x
Boulders			x	x	x	x		x			
Rocks		x	x	x	x	x	x	x	x	x	
Rubble	x	x	x	x	x	x	x	x		x	x
Gravel			x						x		
Shell Hash	x	x									
Sand	x	x	x	x	x	x	x	x	x	x	x
Sand/Shell Hash Thickness (cm)	5-15	5-30+	2	2-4	4	4	2	2-7	<2-10	2-20	5-10
Artificial substrate	x	x	x	x	x	x	x	x	X	x	
Sedimentation	x		x	x		x	x			x	X
Maximum relief (m)	1.0	0.70	0.70	0.90	1.21	0.80	0.90	0.75	1.0	1.5	0.45
Depth Range (m)	15-16	16-18	15-16	17-19	17-19	15-18	16-18	17	14-16	16-18	16-18

3.1.2 Sample Size Adequacy

The emphasis of the visual assessment was to quantify the scleractinian and octocoral populations. The scleractinian species richness and species diversity was assessed using colony counts, colony density, colony size, and colony condition. The number of octocoral genera, density of octocorals, and size of octocoral colonies was also assessed.

As mentioned above, transects were pooled at each random sampling point. For example, at the first random point RP1 of site R2-Z1, four transects were acquired, each 10 m long and 1 m wide, which pooled yielded a single belt transect that was 40 m long and 1 m wide (equivalent to a belt transect area of 40 m²).

Previous studies of the second and third reefs in Broward County, Florida used 30 m² as an adequate sample size to document scleractinian species richness, density, and percent cover (Gilliam et al. 2004). Sample adequacy in Gilliam et al. (2004) was verified using scleractinian species-area rarefaction curves. The optimal sampling area was attained when the cumulative number of scleractinian species plateaued. By pooling transects at each random sampling point in this study, we acquired 41 sets of transects individually ranging from 20 to 40 m² per sample. Samples that were less than 30 m² were excluded from the analysis of species richness and density based on visual assessments. Zones R2-Z1, R3-Z3, R3-C-Z2, and R3-C-Z3 each contained one belt transect equivalent to 20 m². The subtraction of these samples resulted in a sample size of 3 (n=3) at each of these zones. Sample size adequacy was based upon

scleractinian species richness curves because these organisms were the focus of concern for the project.

The adequacy of sample sizes used to estimate coral percent cover based on videographic belt transects was determined by plotting percent cover-area rarefaction curves; adequate sample size was attained when the cumulative sampling area yielded representative cover estimates (Figure 7). In most cases (eight of 11 zones), 16 m² was an adequate sample size. At R2-Z2, R3-Z3, and R3-PI-Z3, 20 m² was an adequate sample size. In a few cases, substrate heterogeneity (particularly at R2-Z2) may explain the need for a greater sample size.

3.1.3 Benthic Organisms

3.1.3.1 Hard Corals-Scleractinians

Species Richness – The number of scleractinian species (species richness, *S*) encountered by reef site and zone within the visual belt transects varied from 9 to 18 (Figure 8). Reef 2 yielded the lowest species richness (*S*_{R2-Z1} = 11; *S*_{R2-Z2} = 9) (Table 6; Figure 8). The highest scleractinian species richness was recorded at R3 and R3-PI (*S*_{R3-Z3} = 16; *S*_{R3-PI-Z3} = 18). The most common scleractinians in decreasing order of abundance were *Siderastrea siderea*, *Stephanocoenia intersepta*, *Porites astreoides*, *Montrastraea cavernosa*, and *S. radians* (Table 7).

Table 6. Number of scleractinian colonies, species richness, and density of scleractinian colonies by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. [*SD* = standard deviation; *N* = number of belt transects; R = Reef; Z = Zone; PI = Previously Impacted; C = Control]

Reef Site-Zone	Colonies	Species	Mean Density (colonies/m ²)	<i>SD</i>	<i>N</i>
R2-Z1	60	11	0.43	0.70	14
R2-Z2	84	9	0.53	0.53	16
R3-Z1	329	13	2.19	0.72	15
R3-Z2	214	12	1.43	0.54	15
R3-Z3	261	16	2.01	1.05	13
R3-PI-Z1	284	14	2.37	0.82	12
R3-PI-Z2	173	15	1.44	0.50	12
R3-PI-Z3	213	18	1.78	0.80	12
R3-C-Z1	204	15	1.28	0.66	16
R3-C-Z2	122	13	0.92	0.43	14
R3-C-Z3	199	14	1.42	1.01	14

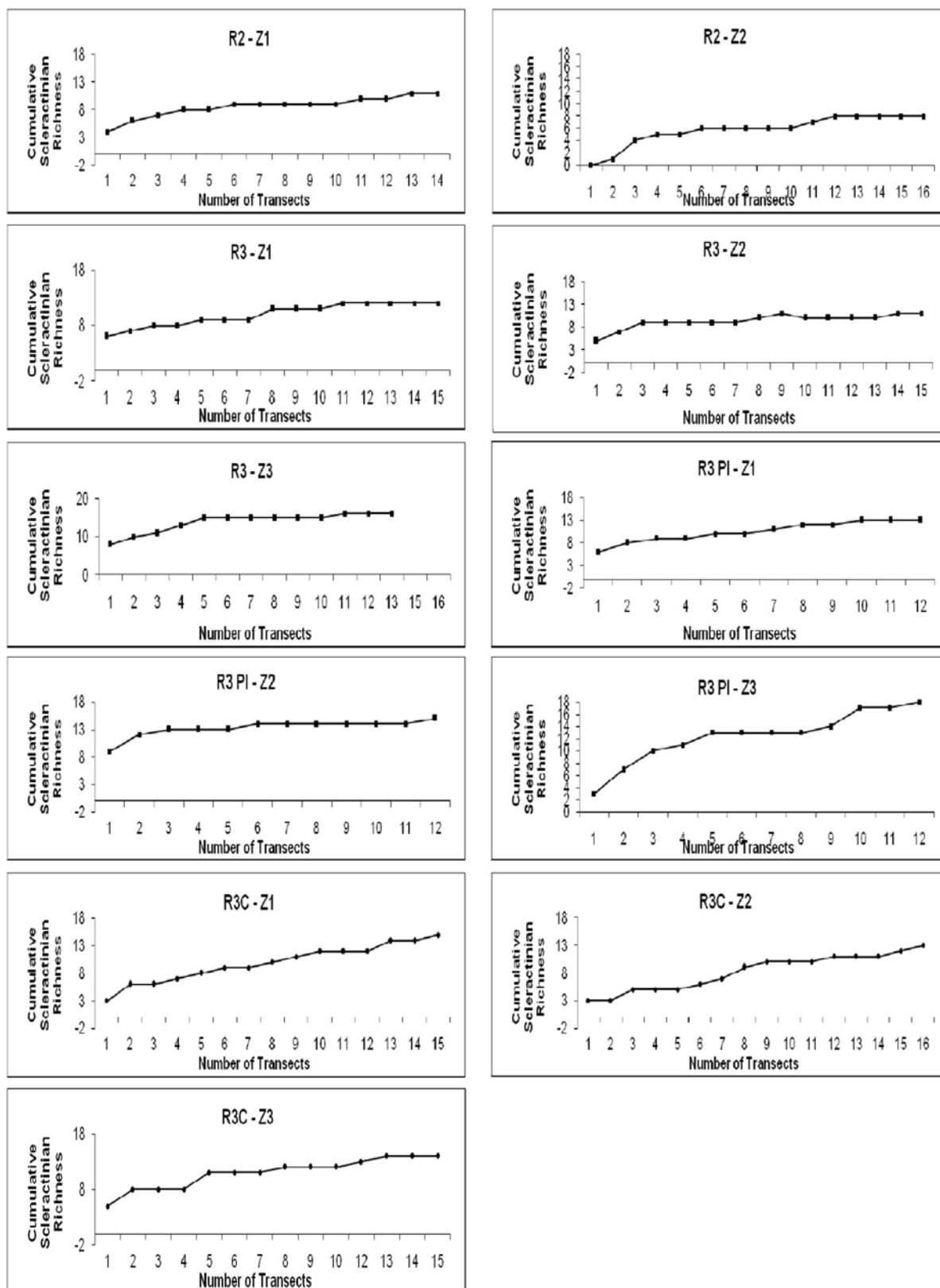


Figure 7. Scleractinian coral species richness rarefaction curves based on visual transects acquired at Reef 2 and third reef sampling sites off Port Everglades, Florida in March 2006

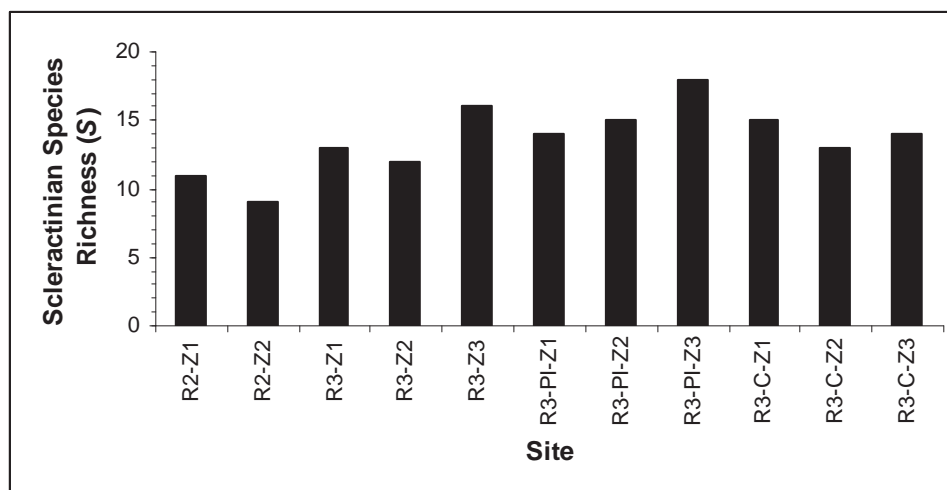


Figure 8. Scleractinian species richness (S) by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]

Table 7. Number of scleractinian colonies by species, reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Species are listed in alphabetic order. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]

Species	R2		R3			R3-PI			R3-C		
	Z1	Z2	Z1	Z2	Z3	Z1	Z2	Z3	Z1	Z2	Z3
<i>Agaricia agaricites</i>	1		4	1	8	1	1	2	2	5	4
<i>Agaricia fragilis</i>							1				
<i>Agaricia humilis</i>								1			
<i>Agaricia lamarcki</i>					1						
<i>Colpophyllia natans</i>		1						1	1		
<i>Dichocoenia stokesii</i>	1		4	8	2	2	6	6	5	1	5
<i>Diploria labyrinthiformis</i>						1		1			
<i>Diploria strigosa</i>	2		2		1	1		2	1		
<i>Eusmilia fastigiata</i>		1						1		1	2
<i>Favia fragum</i>								1			
<i>Leptoseris cucullata</i>											1
<i>Madracis decactis</i>	1	4	5	9	11	8	11	7	8	2	5
<i>Manicina areolata</i>							1	1			
<i>Meandrina meandrites</i>	3	2	7	6	7	2	3	3	2	1	2
<i>Montastraea annularis</i>	5	7	2		5	4	5	8	2	4	7
<i>Montastraea cavernosa</i>	7	11	54	23	28	21	24	25	39	17	28
<i>Mycetophyllia aliciae</i>				2							
<i>Mycetophyllia ferox</i>					1	1			1		
<i>Porites astreoides</i>	3	8	83	20	49	61	16	33	57	20	32
<i>Porites porites</i>			5	1	4	8	2		6	10	12
<i>Scolymia spp.</i>			1	1	1		1				
<i>Siderastrea siderea</i>	21	19	75	57	66	106	38	57	38	37	39
<i>Siderastrea radians</i>	6	5	29	18	13	15	15	17	10	5	8
<i>Solenastrea bournoni</i>					1		1		2	3	2
<i>Stephanocoenia intersepta</i>	10	26	58	68	63	51	48	47	30	26	52
Total	60	84	329	214	261	282	173	213	204	132	199

Mean coral species richness based on visual assessments was not different between Reef 2 zones ($t_{0.05(2),4} = -0.314$; $P > 0.50$). Further, mean coral species richness based on visual assessments was not different between zones within all third reef sites (R3, R3-PI, and R3-C) ($F = 1.91$; $P = 0.10$). Results of a one-way analysis of variance (ANOVA) testing whether differences of species richness existed between zones at all third reef sites (R3, R3-PI, and R3-C) were as follows:

Source of Variation	SS	DF	MS	F	P-value	F crit
Between Groups	0.082214	8	0.010277	1.909531	0.105377	2.355081
Within Groups	0.129163	24	0.005382			
Total	0.211377	32				

Species Diversity – Scleractinian species diversity expressed as H' and based on the number of coral colonies per species collected in visual belt transects ranged from 0.77 to 0.91 (Table 8). The comparison of between-zone species diversity using Hutcheson's modified t-test (Hutcheson 1970) showed that there were significant differences between third reef sampling sites (R3, R3-PI, and R3-C) (Table 9). Reef 3-Previously Impacted-Zone 1 (R3-PI-Z1) was the least diverse, while R3-C-Z3 was the most diverse zone. (Table 8). Reef 3-Previously Impacted-Zone 1 (R3-PI-Z1) was significantly less diverse than R3-PI-Z2 and R3-PI-Z3, all zones in R3-C, and R3-Z3 (Table 9). The most diverse zones were R3-C-Z3 and R3-PI-Z3; they were significantly more diverse than R3-Z1, R3-Z2, and R3-PI-Z1 (Table 8). While species richness at Reef 2 zones was significantly lower compared to all other sampling sites, species diversity (H') was not. In fact, species diversity based on the number of colonies was not significantly different between Reef 2 and any other site ($P > 0.05$).

Table 8. Scleractinian species diversity (H') based on the abundance of coral colonies in visual belt transects off Port Everglades in March 2006. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]

Site	R2		R3			R3-PI			R3-C		
	Z1	Z2	Z1	Z2	Z3	Z1	Z2	Z3	Z1	Z2	Z3
H'	0.86	0.83	0.82	0.81	0.87	0.77	0.89	0.90	0.87	0.88	0.91

Table 9. Significant differences in scleractinian species diversity (H') resulting from Hutcheson's modified t-test (Hutcheson 1970) as applied to coral colony counts in visual belt transects off Port Everglades in March 2006. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]

Significant Differences	Test Results; Level of Significance
R3-Z1 < R3-PI-Z3	$ t_{0.05(2), 410.76} = 2.06$; $P < 0.05$
R3-Z1 < R3-C-Z3	$ t_{0.05(2), 404.19} = 2.42$; $P < 0.05$
R3-Z2 < R3-PI-Z2	$ t_{0.05(2), 366.77} = 2.16$; $P < 0.05$
R3-Z2 < R3-PI-Z3	$ t_{0.05(2), 424.02} = 2.26$; $P < 0.05$
R3-Z2 < R3-C-Z3	$ t_{0.05(2), 411.27} = 2.57$; $P < 0.05$
R3-PI-Z1 < R3-Z3	$ t_{0.05(2), 542.59} = 2.92$; $P < 0.05$
R3-PI-Z1 < R3-PI-Z2	$ t_{0.05(2), 392.94} = 3.18$; $P < 0.05$
R3-PI-Z1 < R3-PI-Z3	$ t_{0.05(2), 419.36} = 3.30$; $P < 0.05$
R3-PI-Z1 < R3-C-Z1	$ t_{0.05(2), 424.19} = 2.56$; $P < 0.05$
R3-PI-Z1 < R3-C-Z2	$ t_{0.05(2), 288.55} = 2.79$; $P < 0.05$
R3-PI-Z1 < R3-C-Z3	$ t_{0.05(2), 380.01} = 3.65$; $P < 0.05$

Colony Density – The overall scleractinian colony density as observed in visual belt transects ranged from 0.43 to 2.37 colonies/m² (Table 6). Scleractinian coral colony density was lowest and most variable at Reef 2 (Table 6; Figure 9). Colony densities were highest at Reef 3 and R3-PI sites. There were significant differences in mean colony densities between zones across third reef sites (R3, R3-PI, and R3-C) ($F = 3.29$; $P = 0.01$). There were, however, no significant differences in scleractinian coral density between Reef 2 zones ($t = 0.092$; $P > 0.50$; $n = 4$). Results of a one-way ANOVA testing whether differences of colony density existed between R3, R3-PI and R3-C zones were as follows:

Source of Variation	SS	DF	MS	F	P-value	F crit
Between Groups	0.179317	8	0.022415	3.299468	0.011021	2.355081
Within Groups	0.163042	24	0.006793			
Total	0.342359	32				

The multiple comparisons of mean densities between all zones across third reef sites (R3, R3-PI, and R3-C) (Tukey test, $P < 0.05$) showed the mean density of scleractinians at R3-C-Z2 was significantly less than at sites R3-Z1 and R3-PI-Z1.

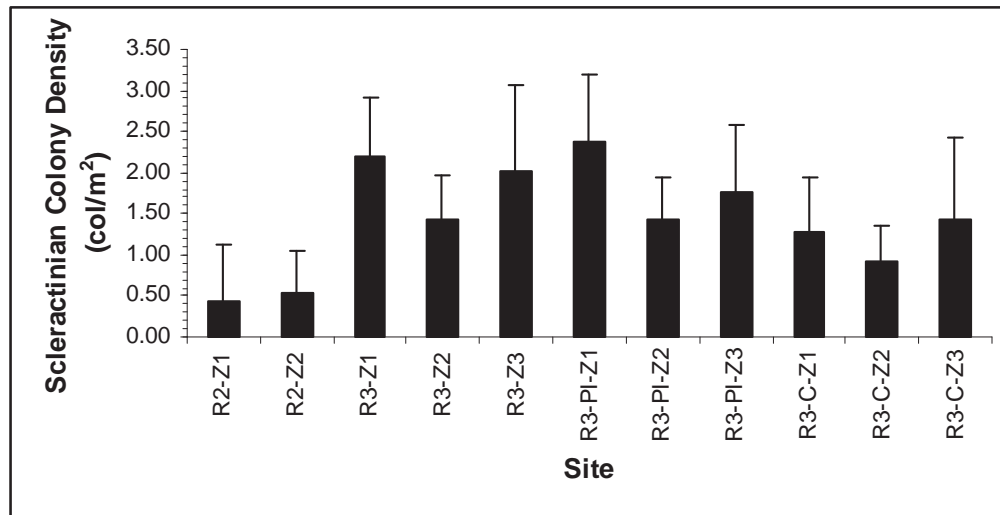


Figure 9. Scleractinian colony density (\pm SD) by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]

Scleractinian Colony Sizes – The size classes of scleractinians observed here were as follows: Class I = 0-3 cm; Class II = 4-10 cm; Class III = 11-25 cm; Class IV = 26-50 cm. These size classes were pre-assigned for this survey. There were no scleractinians with diameters exceeding 50 cm in diameter (Class V). Most scleractinians observed within the visual belt transects (51% to 59% of all scleractinians) belonged to size Class II (Table 10; Figure 10). Class I was the next most common size class (17% to 40% of all scleractinians).

Table 10. Distribution of the scleractinian colony sizes (diameter) by reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Sizes were organized in five size classes: Class I = 0-3 cm; Class II = 4-10 cm; Class III = 11-25 cm; Class IV = 26-50 cm; and Class V = > 50 cm. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]

Reef Site-Zone	Statistic	Class I	Class II	Class III	Class IV	Class V
R2-Z1	Distribution (%)	31.67	51.67	15.00	1.67	
	Colonies	19	31	9	1	0
R2-Z2	Distribution (%)	23.81	59.52	15.48	1.19	
	Colonies	20	50	13	1	0
R3-Z1	Distribution (%)	37.08	51.37	11.55	0.00	
	Colonies	122	169	38	0	0
R3-Z2	Distribution (%)	38.79	52.80	7.94	0.47	
	Colonies	83	113	17	1	0
R3-Z3	Distribution (%)	24.14	55.17	19.16	1.53	
	Colonies	63	144	50	4	0
R3-PI-Z1	Distribution (%)	40.07	54.96	4.96	0.00	
	Colonies	113	155	14	0	0
R3-PI-Z2	Distribution (%)	35.84	52.60	10.98	0.58	
	Colonies	62	91	19	1	0
R3-PI-Z3	Distribution (%)	28.17	58.69	11.27	1.88	
	Colonies	60	125	24	4	0
R3-C-Z1	Distribution (%)	16.67	69.61	10.78	2.94	
	Colonies	34	142	22	6	0
R3-C-Z2	Distribution (%)	25.76	51.52	20.45	2.27	
	Colonies	34	68	27	3	0
R3-C-Z3	Distribution (%)	32.66	53.27	13.07	1.01	
	Colonies	65	106	26	2	0

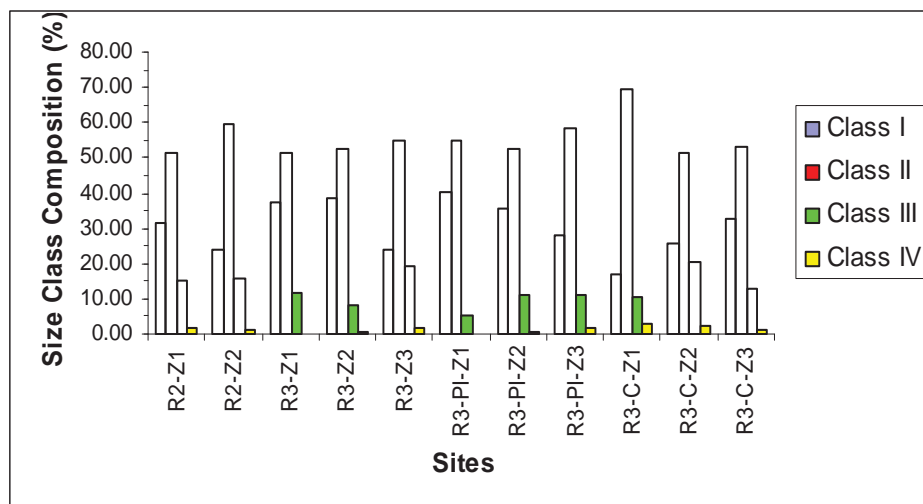


Figure 10. Distribution of scleractinian colony sizes (diameter) within reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Class 1 = 0-3 cm; Class 2 = 4-10 cm; Class 3 = 11-25 cm; Class 4 = 26-50 cm; and Class 5 = > 50 cm. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]

Juvenile corals measure 0.4 cm to less than 5 cm in diameter, and adult corals measure more than 5 cm in diameter (Edmunds et al. 1998). Based on a growth rate of 1 to 3 mm per month, juvenile corals range in age from 1 to 50 months (Edmunds et al. 1998). For the purpose of this report, the scleractinian recruits and juveniles were contained within Class I. Classes II, III, and IV contained adult corals, i.e., corals capable of reproduction. Juvenile corals were not deliberately sought out and no organisms smaller than 1 cm were recorded during the visual assessment surveys.

There were no significant differences in the mean number of size Class I scleractinians between Reef 2 zones ($t = 0.47$; $P > 0.50$; $n = 4$). Within size Class I at third reef sites, there were significant between-zone differences of the mean number of coral colonies ($F = 3.04$; $P < 0.016$). Results of a one-way ANOVA testing whether differences of number of colonies in size Class I existed between zones were as follows:

Source of Variation	SS	DF	MS	F	P-value	F crit
Between Groups	0.929252	8	0.116157	3.040506	0.01649	2.355081
Within Groups	0.916873	24	0.038203			
Total	1.846125	32				

The Tukey multiple means test applied between-zones and across sites showed that R3-C-Z1 had significantly less Class I colonies than R3-PI-Z1 ($P < 0.05$).

There were no significant differences between Reef 2 zones in the mean number of size Class II scleractinians ($t = -0.26$; $P > 0.50$; $n = 4$), size Class III scleractinians ($t = -0.39$; $P > 0.50$; $n = 4$), or size Class IV scleractinians ($t = 0$; $P > 0.50$; $n = 4$). There were significant differences in the mean number of size Class II scleractinian colonies between zones within all third reef sites (R3, R3-PI, and R3-C) ($F = 2.59$; $P = 0.03$). There were no significant differences in the mean number of size Class III coral colonies ($F = 1.83$; $P = 0.11$). There were no significant differences in the mean number of size Class IV scleractinian colonies between zones within third reef sites ($F = 0.79$; $P = 0.60$).

Results of a one-way ANOVA testing differences in the mean number of size Class II octocoral colonies between zones within third reef sites (R3, R3-PI, and R3-C) were as follow:

Source of Variation	SS	DF	MS	F	P-value	F crit
Between Groups	0.51103	8	0.063879	2.596341	0.03362	2.355081
Within Groups	0.590481	24	0.024603			
Total	1.101511	32				

Results of a one-way ANOVA, testing differences of mean numbers of size Class III scleractinian colonies between zones within third reef sites were as follows:

Source of Variation	SS	DF	MS	F	P-value	F crit
Between Groups	0.258557	8	0.03232	1.836384	0.119181	2.355081
Within Groups	0.42239	24	0.0176			
Total	0.680947	32				

Results of a one-way ANOVA, testing differences of mean numbers of size Class IV scleractinian colonies between zones within third reef sites were as follows:

Source of Variation	SS	DF	MS	F	P-value	F crit
Between Groups	0.054275	8	0.006784	0.798527	0.60963	2.355081
Within Groups	0.203906	24	0.008496			
Total	0.258181	32				

Colony Sizes by Species – Among the most common scleractinians encountered here, the diameters of most of the *S. siderea*, *S. intersepta*, and *S. radians* colonies did not exceed 10 cm (i.e., size Classes I and II) (Table 11). Colonies of *P. astreoides* and *M. cavernosa*, two other common species, had diameters that ranged mostly from 4 to 25 cm (i.e., size Classes II and III). Relatively large abundances of these corals in these size classes were recorded at R3, R3-PI, and at R3-C Zones 1 and 3.

Colony Condition – Overall, the scleractinians observed within the visual belt transects were in good condition. There were a few exceptions, some colonies were bleached, some exhibited partial mortality, and others were grown over by algae. Reef 2 had the highest incidence of these types of afflictions (12% of scleractinian colonies at R2-Z1; 6% at R2-Z2). At R3, R3-C, and R3-PI the percentage of afflicted scleractinians ranged from 2% to 3%. Species with the most afflictions were *S. siderea* and *S. intersepta*, which may be an artifact considering that these species were also the two most abundant scleractinians (Table 6). Most of the afflicted corals belonged to size Classes I (0-3 cm) and II (3-10 cm) which may also be an artifact considering that most scleractinians observed here belonged to these size classes (Figure 10). Further, Class IV (26-50 cm) corals that showed some form of affliction were found at R3-C-Z1 and R3-C-Z2 where most Class IV corals were documented (Figure 10).

Table 12 illustrates the individual incidences of afflicted/stressed corals by reef site, zone, and sampling station (RP). The diameter of each colony with an affliction is presented following the species.

3.1.3.2 Hard Corals-Hydrocorals

Other than *Millepora alcicornis*, the only other hydrocoral observed was *M. complanata* which was identified at R3-C-Z1. The colony density of *M. alcicornis* ranged from 0.01 to 0.28 colonies/m² (Table 13). This range of density was low compared to that of the scleractinians (0.43 to 2.37 colonies/m²). As the visual data were being gathered, it was clear that there were few hydrocorals compared to any other sessile organisms. *M. alcicornis* was primarily seen as an encrusting form on artificial substrates such as fishing line and on skeletons of dead octocorals. Therefore, measurements of *M. alcicornis* within the belt transects consisted mostly of encrusted substrates rather than actual diameters of colonies as in the case of scleractinians. Overall, there were very few *M. alcicornis* individuals seen at Reef 2, while more individuals were documented on R3, R3-PI, and R3-C. The majority of *M. alcicornis* were size Class II (4-10 cm) individuals (Table 14).

Table 11. Distribution of the scleractinian colony sizes by species, reef site and zone as encountered in visual belt transects off Port Everglades in March 2006. Sizes were organized in four size classes: Class I = 0-3 cm; Class II = 4-10 cm; Class III = 11-25 cm; and Class IV = 26-50 cm. Species are listed in alphabetic order. [R = Reef; Z = Zone; PI = Previously Impacted; C = Control]

	R2-Z1				R2-Z2				R3-Z1				R3-Z2				R3-Z3				R3-PI-Z1				R3-PI-Z2				R3-PI-Z3				R3-C-Z1				R3-C-Z2				R3-C-Z3					
Size Class	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV						
<i>Agaricia agaricites</i>	0	1	0	0					1	2	1	0	0	0	1	0	1	5	2	0	1	0	0	0	0	1	0	0	0	0	2	0	0	0	1	1	0	0	0	0	4	1	1	3	0	0
<i>Agaricia fragilis</i>																								0	0	1	0																			
<i>Agaricia humilis</i>																												0	1	0	0															
<i>Agaricia lamarcki</i>													0	0	1	0																														
<i>Colpophyllia natans</i>					0	0	0	1																				0	0	0	1	0	0	1	0											
<i>Dichocoenia stokesii</i>	0	1	0	0					3	1	0	0	5	3	0	0	0	2	0	0	1	1	0	0	1	5	0	0	0	5	1	0	2	3	0	0	0	0	1	0	2	2	1	0		
<i>Diploria labyrinthiformis</i>																				0	1	0	0				0	1	0	0																
<i>Diploria strigosa</i>	0	0	2	0					0	0	2	0					0	0	0	1	0	1	0	0			0	0	0	2	0	0	0	1												
<i>Eusmilia fastigiata</i>					0	1	0	0																			0	1	0	0					0	0	1	0	1	1	0	0				
<i>Favia fragum</i>																											0	1	0	0																
<i>Leptoseris cucullata</i>																																										0	1	0	0	
<i>Madracis decactis</i>	0	0	1	0	0	4	0	0	2	2	1	0	0	5	4	0	2	5	4	0	2	4	2	0	3	6	2	0	3	2	2	0	1	7	0	0	0	2	0	0	1	1	3	0		
<i>Manicina areolata</i>																								1	0	0	0	0	1	0	0															
<i>Meandrina meandrites</i>	0	1	2	0	0	1	1	0	2	3	2	0	2	4	0	0	0	5	2	0	0	2	0	0	1	2	0	0	1	2	0	0	0	2	0	0	0	1	0	0	0	1	1	0		
<i>Montastraea annularis</i>	2	3	0	0	0	3	4	0	1	1	0	0					0	1	4	0	3	1	0	0	0	1	3	1	1	2	5	0	1	1	0	0	0	3	1	0	3	2	1	1		
<i>Montastraea cavernosa</i>	0	4	2	1	1	6	4	0	12	26	16	0	8	13	2	0	11	12	5	0	11	8	2	0	4	12	8	0	8	8	8	1	6	23	8	2	1	6	8	2	6	12	9	1		
<i>Mycetophyllia aliciae</i>												0	0	1	1																															
<i>Mycetophyllia ferox</i>													0	1	0	0	0	1	0	0												0	0	0	1											
<i>Porites astreoides</i>	0	3	0	0	0	7	1	0	9	61	13	0	2	18	0	0	1	28	18	2	6	47	8	0	1	13	2	0	2	28	3	0	3	48	5	1	1	15	4	0	6	19	7	0		
<i>Porites porites</i>									0	4	1	0	0	1	0	0	1	1	2	0	5	3	0	0	0	2	0	0					0	6	0	0	2	6	2	0	5	6	1	0		
<i>Scolymia spp.</i>									1	0	0	0	1	0	0	0	1	0	0	0					1	0	0	0																		
<i>Siderastrea siderea</i>	11	8	2	0	8	10	1	0	44	30	1	0	29	23	5	0	24	38	4	0	44	60	2	0	21	16	1	0	28	25	4	0	8	26	4	0	15	19	3	0	18	21	0	0		
<i>Siderastrea radians</i>	3	3	0	0	2	3	0	0	13	15	1	0	7	10	1	0	4	8	1	0	10	5	0	0	10	5	0	0	5	12	0	0	3	7	0	0	2	3	0	0	3	4	1	0		
<i>Solenastrea bournoni</i>																	0	0	1	0					0	0	1	0					0	0	2	0	1	1	1	0	0	1	1	0		
<i>Stephanocoenia intersepta</i>	3	7	0	0	9	15	2	0	34	24	0	0	29	36	3	0	18	38	6	1	30	21	0	0	19	28	1	0	12	34	1	0	10	18	1	1	12	12	2	0	19	32	1	0		